NASA/TM—1998-112216

Director's Discretionary Fund Report for Fiscal Year 1997

Ames Research Center, Moffett Field, California

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 93035-1000

March 1998

Available from:

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Price Code: A 17

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Introduction

The Director's Discretionary Fund (DDF) at Ames Research Center was established to fund innovative, high-risk projects in basic research that are essential to our future programs but otherwise would be difficult to initiate. Summaries of individual projects within this program are compiled and issued by Ames each year as a NASA Technical Memorandum.

These summaries cover 8 final and 24 ongoing projects in Fiscal Year 1997.

The contents are listed alphabetically according to the last name of the primary investigator in two sections (final and ongoing reports). Following the narrative reports, two appendixes (for final and ongoing reports) contain brief descriptions with the financial distribution and status of each of the projects.

Any questions can be addressed to an investigator directly.

Section 1
Final Reports

Software Interface Analysis Tool (SIAT)

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Objectives of the study

To improve effectiveness, productivity, and quality of external interface source code analysis for large, complex, distributed systems being developed in the Ada programming language.

Many of the large software systems being built today are highly distributed, with complex interactions between the software components. Interfaces between software components are particularly hard to verify for correctness, and are, therefore, a major source of software hazard. Interface errors have been implicated in the majority of software failures, especially those in large, safety-critical applications. Such errors have numerous causes, related to the difficulty of coordinating many separate developer organizations working in parallel. The interfaces between components written by different organizations are defined in Interface Control Documents (ICDs). However, it is a complex task to ensure that each component is consistent with the interface definitions, and that the changes that occur as the designs evolve are fully propagated to all the components that are affected. Each software component may support a multitude of interfaces, and there may be large variations in the development maturity across different components and development organizations. Even with the current best practices in the software industry, many interface errors are not detected until system integration or later.

Existing tools provide very little support for verifying that interactions between components in the as-built system conform to the specification. A major weakness is in the ability to trace dataflows across subsystem boundaries. Verifying that the sender is providing the right data at the correct rates, units, and format that the receiver expects and needs is often a difficult and tedious process. Weaknesses in the ability to specify and manage software interfaces, together with the inherent difficulty in verifying external interfaces during the code and unit test phase often result in complications during system integration and test. When problems proliferate to this point, cost, schedule, and mission are jeopardized.

The long-term objective is to build the tool infrastructure necessary for performing verification and validation (V&V) on the new generation of complex, distributed systems. As software systems get larger and even more complex, dependence on manual inspection as the means for verifying software interfaces and determining impacts on proposed changes must be minimized. The ability to adequately perform V&V will depend on the level of tool support that is available to assist the V&V practitioner in efficiently locating and verifying interface data and the related dataflow. The primary objective of this research effort was to identify and prototype new tool capabilities to support the interface analysis process, by:

- extending existing code navigation and browsing facilities to encompass the tracing of dataflow, data use, and data dependencies between Computer Software Configuration Items (CSCIs), and
- developing new techniques for performing consistency analysis between the implemented CSCIs, the design models, the documented software specifications, and interface definitions in the ICDs.

Progress and results

The hypothesis was that there is a correlation between certain programming language constructs and the implementation of distributed system external interfaces, and that, therefore, enough information can be extracted through static analysis of source code, guided by operator queries, to support dataflow analysis across software interfaces. A study was performed against Ada source code from three International Space Station (ISS) CSCIs to test this hypothesis. After examination, it was concluded that certain programming constructs are indeed used in the implementation of CSCI to CSCI data interfaces for distributed systems. On the

ISS program, a synchronous 1553 avionics bus implementation has been adopted.

Significance of the results

The SIAT phase 1 prototype provides ISS analysts with an initial capability to locate, find dependencies, show utilizations, and follow external interface-related data items in the source code units. This SIAT prototype is a significant step forward in providing tool support tailored to the needs of the V&V practitioner. Although numerous commercial off-the-shelf (COTS) products can be effectively utilized in performing V&V, they focus primarily on development or testing activities. The prototype demonstrates that an approach to interface analysis based on guided search for interface-related programming constructs is viable, and that this approach will facilitate the analysis of dataflows across the distributed system.

This initial capability is an improvement over what was previously available for the review of most of the ISS source code. To date, ISS source code has been reviewed in a variety of ways, depending on the development approach taken by the various CSCI development organizations. Some source code review is being performed via the McCabe tool set, which does not include much in terms of data type and data item dependencies, utilizations, and navigation. The main benefits garnered from the McCabe tool set are maintainability and reusability metrics and test-related data points, rather than interface analysis. Other portions of the ISS code are being generated by the MatrixX product design, development, and code generation capabilities, so review is performed both through MatrixX and via desktop editors or word processors. For interface analysis, even the initial SIAT capability may provide a productivity multiplier and increase the quality of the interface and impact analysis work performed.

The phase 1 product is a stepping stone in developing a product that will provide support for geographically dispersed project members to perform source code analysis and move in the direction of automated interface consistency analysis with ICDs. As a result of SIAT phase 1 research and prototyping, valuable feedback was obtained and subsequent SIAT phase 2 development has been funded as a "Center Initiative." The SIAT efforts that are being pursued somewhat parallel those of the HAL language IV&V tool set development, a tool set which has been used widely throughout the Space Shuttle program as the preferred code analysis environment. Significant progress is expected toward building an Ada V&V tool set capability, which even improves on some of the capabilities that are available through the HAL tool set. The result of the SIAT phase 2 effort will be a product that can be applied to any Ada-related program to which V&V is being applied and will advance the understanding of the V&V process for interface analysis and the ways in which interface analysis technology can be extended to other systems and languages.

Keywords

External interface analysis, Ada source code analysis, Ada distributed systems

The Development of a Micromachined Gas Chromatography System for Future Planetary Missions

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Objectives of the study

To develop lightweight, low-power, micromachined, gas chromatographic equipment for future planetary atmospheric probes and soil gas or pyrolytic analysis. A gas chromatography (GC) instrument was used for the Pioneer Venus mission. However, future missions, such as the Mars Exploration Missions, discover missions, and missions to probe outer planet atmospheres or outer planet moons, will require further reduction in weight, volume, and power requirements.

Progress and results

Two problems were found in the micromachined GC detector constructed last year: (1) the discharge gold electrode was burned out after two weeks of operation, and (2) the discharge current was not stable. For these reasons, two new discharge designs were produced.

1. *Submicrometer-sized field emitter tip discharger*
   The submicrometer silicon tips emitter has been demonstrated to produce ions in air or other gases at atmospheric pressure using very low voltages (50V). Using this principle, a submicrometer-sized tip silicon discharge detector was produced (see fig. 1). A formula was designed to prepare a sol gel solution using tetraethoxysilane or tetramethoxysilane, methanol, ethanol, THF, or methyl tert-butyl ether. This sol gel was applied both to glass plate-glass plate and to silicon wafer-glass plate. Because of the difficulty of bonding Pyrex glass and the silicon chip, the detector could not function.
2. *Microporous silicon surface for discharge*
   A possible attempt to get light emission out of silicon is to use nanocrystalline structures. By forming porous silicon films with differently doped wafers and with different anodizing procedures (see refs. 1 and 2) the plasma emission was demonstrated. The second discharge detector of this study is designed using this principle.

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2. Kozlowski, F.; Huber, B.; Steiner, P.; and Lang, W.: Generating a Microplasma with Porous Silicon. Sensors and Actuators, vol. A 53, nos. 1–3, May 1996, pp. 284–287.

Keywords

Gas chromatography, Micromachined, Analysis

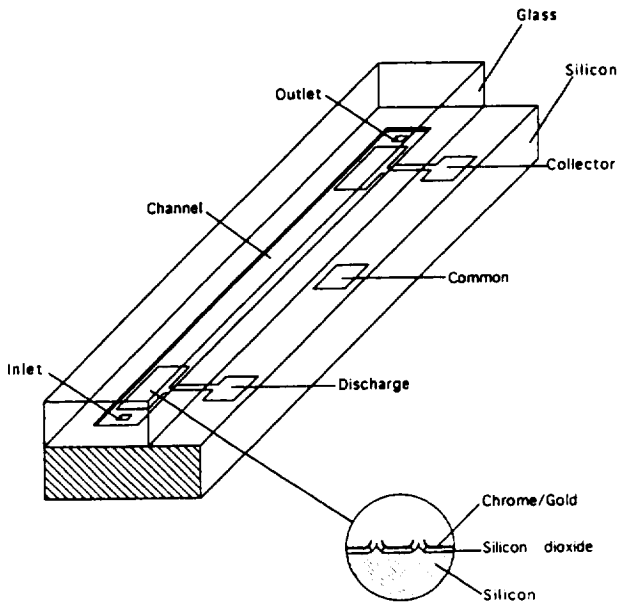

Figure 1. Tip silicon discharge detector.

Planetary Wind Sensor

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Objectives of the study
Hot-wire and hot-film wind sensors have been used on the Mars Viking and Pathfinder missions. Although much useful data have been obtained from these sensors, they have certain disadvantages:

1. Possibility of unknown changes of calibration, particularly in the Martian environment with sand, dust, and extreme temperature changes; full recalibration is not possible on Mars
2. Sensitivity to solar heating and heat radiated from the spacecraft power units
3. Possibility of wire or film breakage caused by wind-driven dust or sand or extreme temperature changes
4. Highly nonlinear characteristics, leading to reduced temperature sensitivity at very high and low velocities
5. Limited accuracy, typically ±10 to 15 percent in wind velocity, ±10° in wind direction

The objectives of this study were to evaluate numerous wind sensing techniques, to rank them, and then select one or two for evaluation in the Ames Aeolian Research Facility. The techniques to be evaluated included:

1. Cup and turbine anemometers and wind vanes
2. Ultrasonic acoustic wind sensors
3. Heat transfer techniques—hot wires, hot films, etc.
4. Pressure measurement techniques
5. Laser Doppler techniques
6. Measurements of oscillations in wakes behind cylinders
7. Mechanical deflection techniques

Based upon the performance of the selected device(s) in the simulated Martian environment, modifications to the selected technique(s) would be made and the modified device re-evaluated in the simulated Martian environment.

Progress and results
First, we summarize the evaluations of the techniques. The cup, turbine, and vane wind sensors would be expected to have bearing reliability problems in the Martian environment with wind-blown sand and extreme temperature changes. Also, with the very low density of the Martian atmosphere, these techniques may not be sufficiently sensitive. The difficulties with the heat transfer techniques were summarized previously. For the lower wind velocities, the pressure measurement and mechanical deflection techniques require the measurement of extremely small deflections, which would appear to be very difficult to do with sufficient accuracy. Further, since extremely small deflections are involved, these techniques could easily be confounded by dimensional changes caused by the large temperature changes that occur on Mars. Laser Doppler techniques would appear to be too complex and require excessive power. Further, the optics are likely to be degraded by wind-blown sand. If the seed material is natural sand or dust, one has no control over it and, therefore, the extent to which it lags behind the gas is unknown. The oscillation frequency behind a cylinder has a limited frequency response, so measurement of the frequency is not possible at very low velocities. Other devices such as hot wires or pressure gauges are required to measure the oscillation frequency and to determine the frequency and wind direction. These devices have their own difficulties, as discussed previously. In summary, each of the described techniques appears to have substantial difficulties.

The ultrasonic technique was selected for further study and evaluation. Commercial units of this type are available for use on Earth. Such a sensor has a simple, fixed calibration (i.e., the distance between the elements) that will not change with time. Its characteristics are linear, with excellent sensitivity down to zero velocity. It is not sensitive to temperature changes and is robust against wind-blown sand.

It contains no lasers, optics, bearings, or other moving parts. It does not depend upon the measurements of very small deflections or flow oscillation behind a cylinder. Finally, at least for units for use on Earth, the sensor accuracy is quite high, ±3 percent for wind velocity and ±2° for wind direction. In the ultrasonic technique, there are 3 or 4 ultrasonic ceramic elements that are placed in a horizontal plane. Each element can either transmit or receive ultrasonic acoustic pulses or waves. By measuring the acoustic transit times in both directions between any pair of elements and knowing the distance between the elements, one may obtain the component of the wind speed parallel to the line between the elements. When this is done for two different pairs of elements, the absolute wind speed and direction can be obtained. A model 425A ultrasonic wind sensor was purchased from the Handar Corporation, Mountain View, California, for preliminary testing and evaluation.

In the Handar sensor, ultrasonic pulse trains are emitted from a tubular ultrasonic ceramic lead zirconium titanate (PZT) element, they pass through the air, and then are received by another identical PZT element. At each interface between PZT and air is a large (factor of ~10^4) mismatch in acoustic impedance and a corresponding inefficiency in acoustic transmission. For the Martian conditions, the acoustic impedance mismatch will be ~100 times worse at each interface and hence, the Handar sensor in its present form was not expected to operate under Martian conditions. The sensor was placed in the Ames Mars wind tunnel and tested at various pressures, wind velocities, and wind direction angles. Wind velocities ranged from 0 to 28 m/s and the sensor was tested at several different angles with respect to the wind. The wind velocity in the tunnel is independently measured using a pitot tube. At a pressure of 110 mbar, the Handar sensor gave reliable results, but the results became inaccurate and erratic at a pressure of 90–95 mbar. Since the pressure at the Martian surface is ~6 mbar, the current Handar sensor would not work satisfactorily on Mars, as expected.

Three techniques that could increase the sensitivity of a Handar type sensor were then examined. The first was the use of horns. It was concluded that horns could not provide the necessary increase in sensitivity and, in any case, they would tend to disturb the flow substantially and thus compromise the sensor results. The acoustic impedance mismatch between the PZT and the Martian atmosphere can, in principle, be reduced by factors up to ~10 if the PZT element is surrounded by one or more layers of materials with acoustic impedances between those of the PZT and the Martian atmosphere. This would still leave the sensor sensitivity on Mars about 100 times less than that of the current sensor on Earth. Further, one might anticipate several practical problems in the use of this graded acoustic impedance stackup on Mars. The large temperature changes, coupled with the very different thermal expansion coefficients of the various materials, may lead to separations between the various annular layers, which could lead to large decreases in the efficiency of acoustic transmission. These same temperature-induced dimension changes could also lead to large stresses and cracking of the ceramic PZT elements. The final technique to increase the sensitivity of the ultrasonic wind sensor is to use low-intensity sparks to generate the sound waves, rather than PZT ceramic elements. (PZT elements would still be used to receive the sound waves.) For Martian atmosphere conditions, using sparks to generate the sound waves is about 10^6 times more efficient than using PZT elements. It was estimated that the required signal intensity at the receiving PZT elements could be achieved with a very low spark power input, 10^{-6} to 10^{-3} W.

Fifteen bare PZT elements were obtained without charge from Handar. As a follow-on to this research, it is proposed to mount one or two PZT elements with their sensing circuitry in a bell jar, together with an appropriate spark source. The bell jar will be pumped down to Martian atmosphere density and the spark source operated to demonstrate that adequate signals can be picked up in this way. After adequate development in the bell jar, the prototype system will be moved into the Ames Mars wind tunnel for further evaluation. Ultimately, this could lead to a space-rated sensor that could be placed on a future Mars probe.

Significance of the results

On previous Mars lander spacecraft, hot-wire and hot-film wind sensors have been used. These sensors have numerous disadvantages. Numerous alternative wind sensing techniques were surveyed, and the ultrasonic acoustic wind sensor proved to be the best candidate for an improved Martian wind sensor. A commercial unit built for use on Earth was purchased and evaluated in the Ames Mars wind tunnel. As expected, this commercial unit would not operate at the Martian atmospheric pressures of ~6 mbar, but would operate satisfactorily only down to about 110 mbar. Several techniques for increasing the sensitivity of the sensor were examined, and it

was concluded that, by using sparks to generate pressure pulses, satisfactory operation could be obtained under Martian atmospheric conditions. It is recommended that follow-on experiments and development work be pursued using spark sound sources and PZT ceramic sound receivers. Ultimately, this could lead to a space-rated sensor that could be placed on a future Mars probe.

Keywords
Martian wind sensor, Ultrasonic wind sensor, Spark sound source

Quantitative Characterization of Porous TPS Microstructures Using Laser Scanning Confocal Microscopy

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Objectives of the study
To explore the capability of laser scanning confocal microscopy (LSCM) to provide quantitative information about the porous microstructure of various thermal protection system (TPS) materials. The idea is to use LSCM to obtain digitally stored representations of the pore structure and to devise computational algorithms to extract numerical values for such quantities as porosity, surface area per volume, pore size and orientation distributions, etc. This information will then be incorporated into various modeling efforts, such as, e.g., internal radiation transport and gas flow in fibrous insulations.

Progress and results
- More experimental LSCM data of fibrous TPS materials have been obtained on LI-2200, AETB-12, and AETB-20 insulation samples.
- Image processing methodologies (e.g., edge definition and enhancement algorithms, segmentation strategies) have been extensively explored to maximize the accuracy of digital reconstructions of fibrous insulation microstructures.
- The 3DMA program has been used to obtain quantitative microstructural information (porosity, specific surface area, connectivity, etc.) based upon voxel counting, stereological relationships, and nth order correlation functions.
- A microstructure analysis program that further processes outputs from the 3DMA code to compute fiber orientation and diameter distributions for fibrous TPS insulations has been written.
- Energy and mass transport simulation codes that predict internal radiative properties and gas permeabilities for fibrous insulations described by experimentally derived fiber orientation and diameter distributions have been written.

Keywords
Confocal microscopy, Microstructure, Imaging, Porous materials, Fibrous materials

NASA Ames Astrobiology Academy

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Objectives of the study
To help guide future leaders of the U.S. Space Program by giving them a glimpse of how NASA operates. Applicants are chosen for this summer institute for their scientific accomplishments, scholarly achievement, and individuality. Another goal is to provide insight into all the elements that make the NASA missions possible, while at the same time assigning the student to one of NASA's best researchers to contribute toward one of its missions.

Progress and results
This summer 11 students interested in Earth science, space science, and space technology were selected from 10 states and Puerto Rico to participate in the 10-week Astrobiology Academy. Four had just graduated and 7 returned to complete their studies in the fall.

The students became Research Associates, contributing their own ingenuity and individuality to shape the academy. One important aspect of the academy is to introduce research associates to the many facets of NASA that contribute to its success as an organization.

Students developed an independent, lab-based project under the direction of NASA scientists, participated in sessions with leaders in government, industry, and academia, visited other NASA facilities and fellow scientific institutions, and led a group project of their choosing.

Significance of the results
The efforts of one participant are expected to lead to a publication in the scientific literature. All the other students contributed in significant ways to the efforts of their principal investigators.

Students visited Dryden Flight Research Center, the Jet Propulsion Laboratory, and the Desert Research Institute in Reno, Nevada. Local visits included Space Systems Loral, Lockheed Martin Missiles & Space, and Stanford University. By invitation from the Planetary Society, the students participated in the Planetfest in Pasadena, California, and the landing on Mars of the Pathfinder spacecraft.

Keywords
Astrobiology, NASA Academy, College students, Summer internships

Does Ultraviolet Radiation Affect Carbon Isotope Fractionation?

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Objectives of the study
To determine if ultraviolet (UV) radiation affects stable carbon isotope ratios. If so, is there an ecologic (e.g., microbial mat vs. phytoplankton) or taxonomic (e.g., prokaryote vs. eukaryote, alga vs. plant) correlation with the effect? These data will provide the basis to present the phenomenon to the scientific community, to estimate how widespread the phenomenon is, and to suggest ways to begin to elucidate the mechanisms underlying the effect. Ultimately this work could lead to a re-interpretation of isotopic ratio studies, including a re-interpretation of the fossil record.

Progress and results
Isotopic measurements and, more specifically, ratios of ^{13}C to ^{12}C in organic relative to inorganic matter, play an important role in interpreting biological activity. In the interpretation of the fossil record, stable carbon isotope ratios are one of the most critical sources of data next to morphological fossils. They are a possible approach for searching for life on Mars. Stable carbon isotope ratios are playing an increasingly important role in analyzing global carbon fluxes, biogeochemical features of modern ecosystems, and community structure (see ref. 1). They have even been used to determine diet in archeological studies.

The stable carbon isotopic composition ($\delta^{13}C$) of a plant or photosynthetic microorganism growing on CO_2 is determined principally by the isotopic composition of the CO_2 as well as any isotopic discrimination associated with CO_2 uptake. Bulk isotopic composition can be further modified somewhat by enzymatic discrimination during the biosynthesis of amino acids, lipids, and nucleotides, and during respiration. To the extent that UV irradiation alters the patterns of carbon flow in an organism, it can also alter isotopic composition.

An experiment was conducted to determine if UV could affect stable carbon isotope ratios in algal communities. Screens were set up that filtered out UVA, UVA + UVB, or a UV-transparent screen, over two types of microbial ecosystems in Yellowstone; one dominated by the red alga *Cyanidium*, and one dominated by the green alga *Zygogonium*. After 90 days of the treatments, the samples were collected, frozen, and analyzed. The results indicate that UV radiation does affect the carbon isotopic signature.

Experiments were then conducted on radishes to examine UV effects on isotope fractionation. Radish seeds were grown in flats on the roof of the lab under different types of UV screening, with approximately 50 plants germinating per treatment. The plants were grown near a blower that controlled temperature and rotated periodically. Isotopic analysis of leaf tissue, which as the site of photosynthesis should be the most sensitive to isotopic shifts, showed no difference among the three UV treatments: full solar UV + PAR (photosynthetically active radiation, 400–700 nm), –UVB, and –UVA + UVB. Unlike the microbial mats where the absence of UV led to a depletion of ^{13}C relative to ^{12}C of several per mil, there was no detectable difference among plant treatments.

Isotopic discrimination in plant leaves is largest when the rate at which CO_2 is supplied to the enzyme ribulose bisphosphate carboxylase (RubisCO) exceeds the enzymatic uptake rate. Discrimination is suppressed to the extent that CO_2 fixation draws down the CO_2 concentration inside the leaves because of leaf stomatal resistance. The $\delta^{13}C$ values of the radish plants were identical under all growth conditions, indicating that the balance between the rates of CO_2 diffusion through the leaf stomata and CO_2 fixation by RubisCO were unchanged under the three UV irradiation regimes.

In contrast, the $\delta^{13}C$ values of the microorganisms did increase with higher levels of UV exposure. This trend cannot be attributed to slower rates of photosynthesis at higher UV exposures,

because $\delta^{13}C$ values would be expected to decrease with a decrease in the rate of photosynthetic CO_2 assimilation, relative to the rate of CO_2 supply to the microbes. This isotopic trend compels another interpretation, which invokes changes in carbon flows elsewhere in metabolism, related perhaps to the synthesis of nucleotides, proteins, or lipids, or to respiration. If the influence of UV on isotopic discrimination in metabolism could be understood, it might allow more precise delineation of the metabolic effects of UV irradiation.

Thus we conclude that UV can affect isotope fractionation in some, but not all, photosynthetic organisms.

References

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Keywords

Isotope fractionation, Photosynthesis

Use of Evolving Microbial Systems as a Domain for Development of Autonomous Artificial Intelligence Software

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Objectives of the study

To achieve advances in artificial intelligence (AI)-based software technology for control, diagnosis, and repair of complex microbial experimental systems, and to gain a better understanding of the role that nitrogen-fixing and denitrifying microbial systems play in nutrient cycling, atmospheric evolution, and biogeochemical (BGC) cycles on Earth.

Progress and results

Pseudomonas fluorescens, *Serratia marscens*, and *Clostridium perfringens* were all grown in the bioreactor system, each under appropriate conditions, to determine growth rates and nitrogen use characteristics. *C. perfringens* was also grown in competition with *S. marscens* to initiate a series of competition experiments. These experiments are being continued in order to test the validity of a model of the evolution of nitrogen cycling (ref. 1). The bioreactor system was used for the first real-time demonstration of control using a Livingstone (model-based autonomy software) qualitative model of the thermal control subsystem. Integration of hardware using conventional control software with advanced AI autonomy software was demonstrated for several key subsystems (thermal control, biological modeling). A theory for unifying symbolic reasoning methods with conventional feedback control methods was completed and presented.

Significance of the results

The autonomous control software could be applied within NASA; for example, Advanced Life Support, Office of Space Science, and Autonomous Spacecraft.

Publications resulting from the study

Smernoff, D. T.; and Mancinelli, R. M.: Co-organizers of a Half-Day Symposium on the Bioreactor System, in the 1998 International Society for Ecological Modeling Program "Issues in Trophic Systems Synthesis," Ecol. monographs, 1998 (in preparation).

Robinson, Peter: Autonomous Design and Execution of Process Controllers for Untended Scientific Instruments. Proceedings of the 1997 1st International Conference on Autonomous Agents, Marina del Rey, Calif., Feb. 5–8, 1997, ACM SIGART, New York, N.Y., pp. 546–547.

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Keywords

Nitrogen cycling, Bioreactor, Autonomy, Control systems

Modeling High-Energy Aerocapture Trajectories for Outer Planet Orbiter Missions

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Objectives of the study

First, to characterize the static aerodynamic coefficients of the axisymmetric biconic shape in realistic flow conditions representative of actual flight trajectory, including the lift and drag coefficients of the entry vehicle at various angles of attack; second, to calculate the heating distribution over the surface of the entry vehicle at various trajectory points; and finally, to determine thermal protection system (TPS) requirements from the coupled heating distributions at several trajectory points. With this analysis, an attempt to incorporate approximate methods of estimating the heating distribution (and subsequent thermal protection material requirements) with an actual trajectory simulation will be assessed and performed if appropriate.

Progress and results

A high-fidelity three-degree-of-freedom aerocapture trajectory simulation code that included all necessary input variables to adequately model atmospheric flight in Neptune's atmosphere was developed. Such variables as vehicle aerodynamics, planet rotation effects, and atmosphere structure were included. Subsequently, a comparison of biconic aerodynamics, which compared Newtonian predicted lift and drag coefficients with full three-dimensional (3-D) Navier–Stokes (NS) solutions using the General Aerodynamic Simulation Program (GASP) 3.0, was performed. The solutions used H2-He finite-rate chemistry and vibrational equilibrium and modeled an axisymmetric biconic shape at various Reynolds numbers and angles of attack. With improved aerodynamics, trajectory simulations were improved. Heating distributions were estimated for the biconic shape over a wide variety of entry conditions. With the capability to evaluate the impact of entry parameters such as entry velocity, lift/drag ratio, etc., on overall aerothermal heating, it is possible to make design choices that were previously not possible.

Next the effort focused on refining the entry trajectory based on improved aerodynamics from the GASP computational fluid dynamics (CFD) solutions. GASP was used to compute the 3-D flow fields in this study. GASP is a finite-volume code with a variety of solution techniques. An implicit two-factor approximate factorization algorithm with relaxation in the streamwise direction was used in the time integration of the thin-layer NS equations. Third-order, Van Leer flux vector splitting method was used to discretize the inviscid fluxes. To prevent possible oscillations in the solution due to higher order interpolations, a Min-Mod flux limiter was used. Blottner curve fits were implemented for all species in the chemistry model to obtain laminar viscosity. A simple binary diffusion model in which the Schmidt number is a constant was implemented in GASP. The thermochemistry model used the species H, H2, and He and a set of the following three reactions:

$$\begin{aligned} H + H + H2 &\rightarrow H2 + H2 \\ H + H + H &\rightarrow H2 + H \\ H + H + He &\rightarrow H2 + He \end{aligned}$$

Local thermodynamic equilibrium is assumed and finite-rate chemistry with complete chemistry source term linearization in the implicit time integration. The implemented model neglects ionization.

The boundary conditions used in GASP are explicitly integrated. Since the Neptune probe geometry considered is symmetric about the x-z plane, only half of the body was considered. The appropriate boundary conditions are applied such that the flow quantities are computed by reflecting the interior values about the x-z plane. For the inflow boundary conditions, all flow quantities are

fixed to the free-stream conditions. The outflow boundary condition is supersonic, extrapolated from the interior. The surface of the vehicle is assumed to be nonablating, with a fixed wall temperature to 3000 K. A no-slip velocity boundary condition and zero pressure gradient are imposed at the wall. Figure 1 shows some of the results of the GASP CFD analysis.

TPS sizing computation was performed using the Fully Implicit Ablation and Thermal Response (FIAT) program. The nonablating aerothermal heating history was derived using the GASP code. To account for the heating reduction due to surface ablation, the blowing reduction parameter of 0.5 was used in the FIAT computation. The back face of TPS material was assumed to be adiabatic for conservatism. The initial temperature was 10°C, and the maximum bond-line temperature used for sizing was 250°C. The total time for heat soak was 1500 sec. The candidate TPS materials used in this computation are PICA-15 (15 lb/ft^3) and carbon-phenolic (90 lb/ft^3). The sizing results presented include four cases. In case 1, the surface is completely covered with carbon-phenolic, and in case 2, the surface is covered with PICA-15. The total TPS mass of case 1 (248 kg) is about three times as high as that of case 2 (88 kg). However, the stagnation point recession for PICA-15 is about 7 cm, and that for carbon-phenolic is only about 1 cm. In cases 3 and 4, the surface area with low heat load is covered with PICA-15 (in gray), and the rest is carbon-phenolic (in black). Cases 3 and 4 may reduce the surface recession, but have higher total mass compared with case 2. Figure 2 shows results of the TPS sizing.

Significance of the results

The analysis to date has performed calculations never before undertaken, such as modeling aerocapture trajectories and simulated biconic flow field. The capability to estimate heating distributions has enabled evaluating various aerocapture design issues. This DDF effort has demonstrated the capability to determine high-fidelity aerothermal estimates using CFD tools developed primarily for Earth environments as well as applying the aerothermal environments to a trajectory-based TPS sizing estimate. Furthermore, the TPS sizing analysis has shown the overall feasibility of the concept of aerocapture at Neptune since the heat-shield TPS mass estimates are within bounds specified by the spacecraft designers.

Keywords
Aerocapture, Neptune orbiter, Flow-field calculations

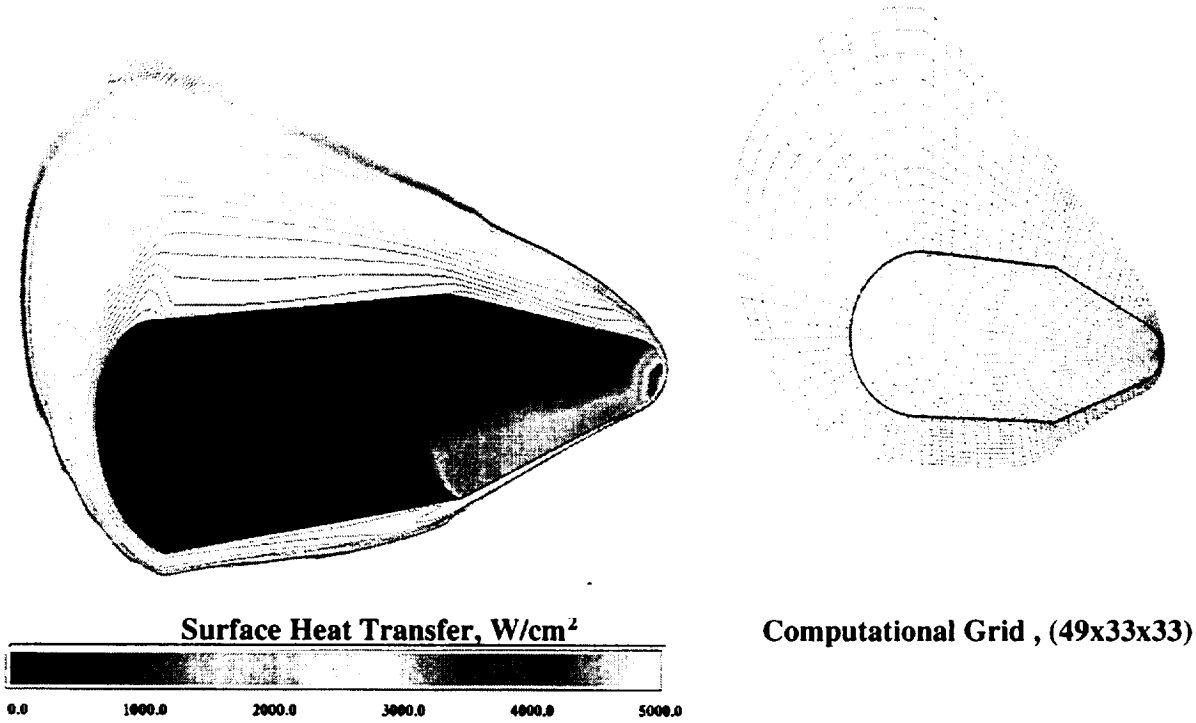


Figure 1. GASP CFD solution for surface heating conditions at peak heating (nonablating, t = 149 s).

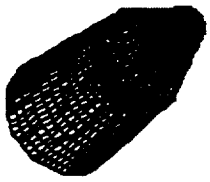
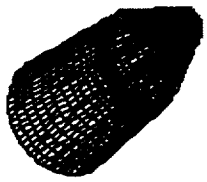
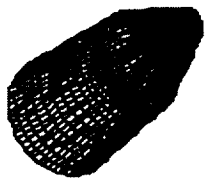
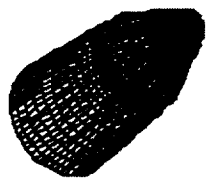
	Case 1	Case 2	Case 3	Case 4
				
Carbon Phenolic (black)	248 kg	0	58 kg	96 kg
PICA-15 (gray)	0	88 kg	74 kg	62 kg
Total	248 kg	88 kg	132 kg	158 kg

Figure 2. Preliminary TPS sizing for Neptune aerocapture vehicle. Assumptions include: back face condition: adiabatic wall; initial temperature: 10°C; bond-line temperature: 250°C; time (final): 1500 sec; total TPS area: 5.3 m^2.

Section 2
Ongoing Reports

Gas-Phase Spectroscopy of Interstellar PAH Analogs

Investigator(s)
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Farid Salama, SETI Institute, Ames Research Center

Objectives of the study

To investigate the potential interrelationship between interstellar polycyclic aromatic hydrocarbons (PAHs) and the carriers of the diffuse interstellar bands (DIBs). The goal is to measure, for the first time, the gas-phase spectra of selected neutral and ionized interstellar PAH analogs to allow a decisive test for these species as potential DIB carriers. These goals can be achieved by using the combined techniques of supersonic free-jet expansion spectroscopy (JES) and laser absorption spectroscopy (LAS).

Progress and results

A feasibility study of the project has been performed and a new experimental setup for the jet supersonic expansion has been designed. The feasibility study consisted of calculating all the optimal experimental conditions (diameter of the nozzle, size and structure of the expansion chamber, appropriate working range for the background, and residual pressure) needed to generate a supersonic jet where the PAH molecules are vibrationally and rotationally cold (10 and 100 K, respectively) and fully isolated from each other. These conditions are essential to simulate the physical conditions known to exist in the diffuse interstellar medium and to remove the spectral congestion observed/expected with such large polyatomic molecules when probed using more classical analytical techniques. The experimental setup required for such a study consists of a high-pressure gas reservoir connected to a pulsed nozzle. The pulsed beam is then expanded in a vacuum chamber, where it can be probed by a laser. The vacuum hardware (expansion chamber and precision manipulators), the pulsed nozzle, and the pumping stations have been either built and/or ordered. The next step is to mount the supersonic jet expansion chamber and measure the first ultraviolet, visible, and near-infrared spectra of a few selected, free, molecular PAHs in their neutral and ionized forms.

Keywords

Astrobiology and prebiotic aromatic molecules and ions; Supersonic jet electronic spectroscopy (SJES); Polycyclic aromatic hydrocarbons and environmental studies

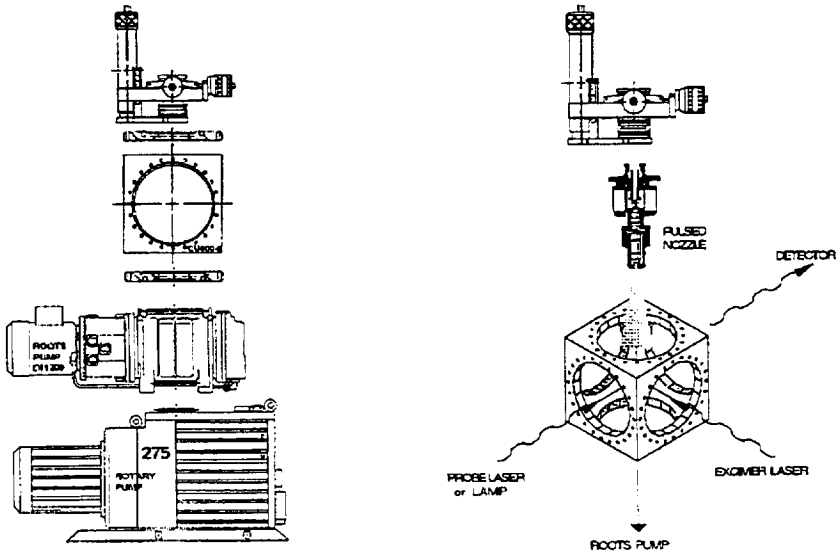

Figure 1. Supersonic jet expansion chamber.

Development of a Tethered-Glider Probe-Positioning System for Use in Wind Tunnel Testing

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Objectives of the study

To demonstrate the feasibility of using a tethered glider with an onboard, miniature, data-acquisition system and flight-control system as a minimally intrusive, probe-positioning system in a large-scale wind tunnel environment.

Progress and results

The design of the glider airframe is currently under way. An initial configuration has been established, and aerodynamic analysis and configuration refinement are being performed using the low-order potential flow panel code PMARC. Results from PMARC will be used to establish the stability derivatives that will be used in the flight-control system. Design of the glider should be complete by December 1997, with construction to begin in January 1998.

The glider will have two independent position and attitude determination systems. The first system to be used for position and attitude determination is the onboard inertial navigation system (INS). This system also provides angular and linear acceleration information for the flight-control system. The solid-state gyroscopes and linear accelerometers to be used for the INS have been identified and are being procured. The software to acquire angular velocity data and to integrate it for attitude is being developed.

While the output of the INS can be integrated to obtain attitude and position information, which is reasonably accurate over short periods of time, integration error becomes a problem over long time periods. Thus a second, absolute, position and attitude determination system is being explored. Currently, two systems have been identified that would meet the requirements for this application. The first, a local Global Positioning System (GPS) that uses pseudollites, is being developed at Stanford University. The second system, which could be used for absolute position and attitude determination, is a commercially available optics-based system known as OPTOTRAK. An OPTOTRAK system is available at NASA Ames.

The flight-control hardware has been assembled and tested. The system consists of a PC/104 CPU and analog to digital converter (ADC) unit and commercially available servomotors. The servomotors are driven by the parallel interface of the PC/104 flight computer. The flight-control software is currently being written. The servomotor driver interface has been written and tested. A manual emergency backup control system (commercial radio control) has been purchased for use in the event of a flight computer failure and also for flight-testing the glider prior to use in the tunnel.

The miniature data-acquisition system has been completed and tested. It comprises a PC/104 CPU and ADC unit. The system can acquire 16 channels of analog data at a maximum data rate of 500 Hz per channel. Data are continually transmitted from the onboard system via free-space infrared link or twisted-pair wires through an RS-422 port. The overall size of the complete data system is approximately $3.6 \times 3.6 \times 4.5$ inches.

The tether system for the glider has been defined. It comprises a single, main tether whose length is actively controlled using a stepper motor and controller and a minimum of two safety tethers that play no role in positioning the glider. The stepper motor and controller are currently being tested. The length of the main tether controls the positions in the wind tunnel that can be reached by the glider.

Keywords

Flow surveys, UAV, Data acquisition

Visual Servo-Control Applied to Mobile Robot Navigation

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Objectives of the study

To develop a visual approach to short-range and terminal mobile robot navigation. Visual servo-control techniques for mobile robots will be developed; these techniques will be implemented on board under realistic computing and telemetry constraints; and this approach will be demonstrated in realistic outdoor field experiments. In addition, obstacle avoidance techniques will also be integrated with visual servo-control, and performance will be quantified and compared to traditional methods.

Progress and results

The hardware, software, and programmatic infrastructure has been built. A dual Pentium computer system with video digitizers, a pan-tilt-vergence device, and a pair of cameras have been purchased and integrated into a testbed system. The basic visual tracking and robot control software for the new computing platform has been written and debugged. Finally, discussions have begun with the Mars 2001 mission to determine how to best apply this research to Mars exploration.

The major technical results of the first year address the three dominant failure modes of visual servo-control: target loss due to robot motion and subsequent appearance change, above-threshold correlation for an erroneous target (false positive), and correlation that slowly drifts off the target because of weak feature texture. A neural network system that may solve the first of these problems is being tested. The neural network predicts the target shift in the input image based on rover and camera mount sensor information. Initial results show that the system reduces the number of tracking failures by 50 percent or more. To combat the drifting target problem, a hierarchical correlation scheme in which two correlations are performed for each control cycle has been implemented. First, a correlation is performed at half resolution over a large portion of the input image. Then a second correlation is made at full resolution over a smaller search area that is based on the previous correlation result. This system has been tested in outdoor trials on the Marsokhod rover. Discussions with the Jet Propulsion Laboratory about porting this system onto their testbed rovers are ongoing.

Significance of the results

The ability of robot rovers to reach a wide variety of samples and perform analyses on each one is crucial to the success of the surface exploration objectives of the Mars Surveyor program. Traditional techniques for spacecraft navigation are unsuitable for roving vehicles, and worse, they make the vehicle more complex, heavier, and more vulnerable to failure. Visually servoed navigation provides an innovative navigational alternative, consuming little power and telemetry and making use of imaging hardware already baselined for proposed rover missions. Initial results prove the feasiblity of such a system using the limited computational power of the types of processors that will fly on the near-term missions. The visual servoing technique will drastically reduce the ground-control needs for rover missions, with a subsequent reduction in mission costs and an increase in science return.

Keywords

Visual servoing, Computer vision, Robot navigation, Planetary rovers

Active Control of Instability Waves in a Laminar Boundary Layer

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Anthony Dietz, MCAT Institute, Ames Research Center

Objectives of the study

To develop and test an active wave cancellation scheme for the control of transition in a laminar boundary layer. The scheme uses distributed disturbance sources to excite control waves that are out of phase with the boundary layer instability waves excited by free-stream disturbances. Superposition of the control waves on the instability waves reduces the magnitude of the instabilities and hence delays transition of the flow into turbulence. The use of spanwise distributed sources for the control wave introduces the possibility of canceling three-dimensional wave packets. Another important aspect of the investigation is the use of artificially generated two- and three-dimensional free-stream disturbances to excite the boundary layer. Repeatable disturbances are necessary to provide a known input to the control scheme, allowing detailed study of the cancellation process and optimization of the control algorithms. When a satisfactory control scheme has been obtained, it will be evaluated against random three-dimensional instability waves excited by free-stream turbulence.

Progress and results

The test plate and control unit have been designed and manufactured. The control unit consists of an array of 24 microphones and 8 speakers mounted in a cavity on the lower side of the test plate. The mounting arrangements for the microphones and speakers were determined from tests and analyses performed to optimize the frequency response of the sensors. The wind tunnel data acquisition and processing capabilities have been expanded to cope with the increased number of channels and the real-time processing requirements of the control unit. Software control of the new hardware was implemented using LABVIEW graphical programming software. A technique has been developed to generate repeatable three-dimensional free-stream disturbances to complement the two-dimensional disturbances generated in the facility by a vibrating ribbon. A low-aspect-ratio wing made from 0.001-inch stainless steel shim is given a pulse displacement. When the pulse disturbance from this wing interacts with a roughness element on the plate surface, it excites a three-dimensional wave packet similar to that excited by free-stream turbulence. Initial testing of the control scheme with two-dimensional disturbances is under way, and tests and optimization with three-dimensional disturbances will continue through the next fiscal year.

Significance of the results

The potential benefits of laminar flow control in reducing aircraft or ship drag and improving manufacturing processes are large and justify the pursuit of numerous control techniques. The few wave cancellation studies carried out previously have involved surface-generated instability waves or uncontrolled free-stream-generated waves, limiting the breadth of the studies and the degree to which the cancellation technique could be optimized. In addition, there has been no concentrated effort to introduce or cancel any three-dimensionality in the instability waves. The results from this experiment involving the control of known and repeatable two- and three-dimensional instability waves will add a wealth of new information on the feasibility of active transition control.

Keywords

Boundary layers, Laminar flow control, Active flow control, Transition

The Early History of the Biogeochemical Carbon Cycle Can Be Illuminated by Isotopic Microanalyses of Rocks Using a UV Laser

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Objectives of the study

Stable carbon isotopic measurements of carbon reservoirs in ancient sedimentary rocks offer a valuable insight into the early history of our biosphere. For example, the stable isotopes ^{12}C and ^{13}C are utilized at different rates by biological processes. Therefore, certain differences in $^{13}C/^{12}C$ values between preserved organic matter and inorganic carbon minerals can be interpreted as "isotopic fossils" of metabolism. Also, through isotopic mass balance calculations, changes in the inventories of sedimentary carbon reservoirs can be charted over geologic time.

Major advances in interpreting patterns of $^{13}C/^{12}C$ values in ancient rocks will depend upon our ability to sample in situ very small bits of carbon-containing material. These challenges could be met by a microsampler system that volatilizes sample targets in the size range from 1 to 100 μm. Such a technique would also greatly facilitate the analyses of meteorites and planetary materials.

We proposed to develop and verify the performance of a laser-based microsampler that could reliably release carbon from organic matter or carbonate in a 3- to 100-μm-diameter spot size and convert this carbon to CO_2 for stable isotopic analysis. "Reliably" means that the isotopic discrimination associated with the process is either insignificant or else highly reproducible. Organic carbon should be combusted quantitatively. Carbonates should be converted principally to CO_2, and any other products should also be analyzed to yield accurate measurements of $^{13}C/^{12}C$ and $^{18}O/^{16}O$. Ultimately, samples as small as 10^{-10} moles should be produced in order to take full advantage of state-of-the-art isotope mass spectrometry.

Progress and results

The microsampler incorporates a laser and microscope system that is commercially available. The frequency quadrupled Q-switched Nd:YAG laser has a 266-nm output, which will generate up to 1.6×10^{12} joules/cm^{2}s onto a spot 10 μm in diameter. This laser decomposes carbonates to CO_2 by photoexcitation. The laser can photoexcite organic carbon, causing it to combust in the presence of O_2. The laser's power output can be attenuated and the spot size adjusted from 5 to 300 μm. The microscope's view is coaxial with the laser beam and has image magnifications ranging from 50x to 1000x. A sample chamber that is movable, relative to the laser beam, will be constructed using a motor-driven x-y stage. The sample chamber will be interfaced with our existing Nuclide 6-60 RMS isotope mass spectrometer, which can analyze samples as small as 10^{-8} moles. In June, 1998, a Finnegan Delta+ mass spectrometer that should lower the sample requirement to 10^{-10} moles will be acquired. Then previously characterized carbonate rocks will be analyzed to verify that the new technique recreates the $^{13}C/^{12}C$ patterns previously recognized among the various generations of carbonate.

Significance of the results

A major objective of exobiology is to interpret the early evolution of life on Earth and to search for evidence of prebiotic and/or biologic evolution elsewhere in the universe. A key part of this evidence resides in rocks that have incorporated the remains of biota and/or prebiotic organic matter. This material is preserved at the submillimeter size range. Therefore, a need clearly exists to perform microanalyses at the scale of tens of μm or less.

There are several novel elements in this work. This is the first use of an ultraviolet (UV) laser for isotopic microanalysis. This will be the first laser-assisted combustion of organic carbon for stable isotopic analysis. Also, these will be the first subnanomole-sized carbon samples to be measured isotopically.

The addition of this laser system will help to establish Ames as a leader in the isotopic microanalysis of a wide variety of extraterrestrial materials of interest to exobiology. Advanced methods in microanalysis will help to position Ames as a

possible future recipient of a returned Mars sample, which is now a key objective for the currently funded Mars Surveyor Program.

Keywords
Laser, Rocks, Carbon

Remembering To Do Things in Dynamic Environments

Investigator(s)
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Objectives of the study
To develop an experimental paradigm with which to study prospective memory for the types of tasks performed by air traffic controllers; and to determine factors that influence the probability of prospective memory (PM) errors.

Progress and results
The following tasks have been performed:

- Review of the relevant scientific literature
- Review of National Transportation Safety Board (NTSB) accident reports
- Review of Aviation Safety Reporting System (ASRS) incident reports involving controller errors
- Controller interviews
- Development of a conceptual framework for the cognitive mechanisms underlying prospective memory errors
- Design of an experimental paradigm for prospective memory tasks analogous to those of controllers

Although literature on memory research abounds, most studies address *retrospective* memory, in which an experimenter gives subjects some material to memorize and at some later time asks the subjects to recall the content of the material. By contrast, in *prospective* memory, subjects must remember an intention to perform some action that must be deferred. The conceptual framework of the present study posits that PM does not require unique cognitive mechanisms but rather draws upon general memory mechanisms in unique ways because of the nature of the task. The study hypothesizes that success or failure at PM hinges on:

- The elaboration of the intention in long-term memory
- The availability of environmental cues to trigger retrieval of the stored intention at the appropriate time
- The nature of other tasks ongoing at the time the PM task is to be performed

The main experimental paradigm consists of a visual display in which targets with associated datablocks enter and leave a rectangular pattern controlled by the subject. At irregular intervals, the subject is instructed to cause one of the targets to deviate from the normal routing when it reaches a predetermined point, and the subject must remember this instruction. With this paradigm, a range of pertinent factors can be manipulated, including the duration the intention must be retained; the availability and character of cues to remind the subject of the intention; the workload of the ongoing task; and the relationship of the PM task to the ongoing task. This somewhat complicated paradigm is currently being programmed. In addition, data are being collected with a simpler experimental paradigm in which subjects' performance is examined when the window of opportunity to perform is defined by time rather than an event-based trigger.

Keywords
Prospective memory, Air traffic controllers, Memory for intentions

Martian Fossils in the ALH84001 Meteorite: An Independent Assessment of the Evidence

Investigator(s)

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Objectives of the study

To re-evaluate the biogenicity of microfossil-like features found in the Martian meteorite, ALH84001, based on detailed comparisons to terrestrial analogs of known origin. To achieve this goal we seek to: 1) use nutrient limitation methods to derive an empirically based estimate for the lower size limit achieved by four species of small heterotrophic microbes from hydrothermal environments considered good analogs for ALH84001; 2) re-evaluate the biogenicity of features commonly found in terrestrial rocks that have been broadly referred to as "nanobacteria"; 3) document the effects of contemporaneous mineralization on the fossilization potential of small bacteria, particularly those found in hydrothermal environments; and 4) make direct mineralogical and microstructural comparisons of terrestrial analogs of known origin and the putative nanometer-scale microfossils of the ALH84001 meteorite.

Progress and results

Four species of thermophylic heterotrophic bacteria typical of environments postulated for the Mars meteorite were successfully isolated and cultured. Nutrient limitation experiments were used to evaluate the lower size limit for these species under conditions of starvation typical of deep subsurface environments. Critical point drying methods and scanning electron microscopy were used to characterize experimental cultures and obtain morphometric data on cell size.

Significance of the results

Our culture-based analog studies are important for providing an experimental framework for testing hypotheses about what controls the lower size limit of living cells and for establishing an empirical lower size limit for life to which theoretical arguments can be compared. In addition, in vitro biomineralization and fossilization studies are important for establishing a baseline for comparing nanoscale morphological features observed in the ALH84001 meteorite and for ancient rocks on Earth. The establishment of reliable criteria for recognizing the biogenicity of morphological structures preserved in ancient rocks is extremely important for improving our accessibility to the early history of the Earth's biosphere, and is also essential in exploring for past life on Mars when samples are returned to Earth early next century.

Keywords

Mars, Meteorite, ALH84001, Exopaleontology, Biogenicity, Fossils

Remote Sensing of Aircraft Contrails Using a Field Portable Imaging Interferometer

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Other personnel involved
Stephen Dunagan and Anthony Strawa, Ames Research Center

Objectives of the study

To measure visible and infrared radiative effects of aircraft contrails to provide information about their spatial distributions, their microphysical properties (especially ice crystals), their time evolution, and their surroundings by application of a novel remote sensing technique, imaging interferometry. The instrument concept to be utilized is called DASI (digital array scanned interferometry). These measurements will be made from the ground at appropriately selected sites. Analytical techniques employing atmospheric radiative transfer methods will be developed and applied to analysis and interpretation of the spectral images. The overall objective is to demonstrate the feasibility of this measurement technique for remote sensing of contrail properties, and more generally, of aerosol plumes.

Progress and results

In early May 1996, measurements were made during NASA's subsonic aircraft contrail and cloud effects special study (SUCCESS). Ground-based measurements were made of aircraft contrails and cirrus clouds at the Department of Energy's Cloud and Radiation Testbed (CART) site in Oklahoma. DASI spectral images were acquired for both commercial aircraft and SUCCESS mission aircraft atmospheric radiative effects. These measurements were acquired together with those of other participating sensors. Simultaneously, airborne and satellite-based measurements were also acquired by collaborating investigators.

A new infrared DASI sensor with improved characteristics has been developed. Additional ground-based measurements of aircraft contrails will be made after a new lens system for this sensor is acquired. The improved infrared instrument will permit obtaining images with good spatial resolution over the entire spectral range of 4000 to 11,000 cm^{-1} (0.91 to 2.0 microns). The anticipated high-quality measurements will enable completion of the study.

Significance of the results

The results from the May 1996 measurements have met the following analysis goals: 1) determination of spatial features, extent, and short term-time evolution of the contrails; 2) assessment of spatial distributions—mapping of variations in cirrus optical properties; 3) collection of information about the atmosphere in the vicinity of contrails; and 4) qualitative extinction and scattering optical depth information. The improved DASI sensor, expected to be ready during 1998, should allow completion of the project.

Keywords

Aircraft contrails, Remote sensing, Imaging spectrometers

A Modeling Approach to Global Land Surface Monitoring with Low-Resolution Satellite Imagery

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Other personnel involved
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Objectives of the study
A new approach to developing accurate estimates of global extents of land use/land cover types with maps derived from satellite imagery is being developed. This objective is being accomplished by: 1) testing models of the size distribution of patches of specific cover types, as mapped with imagery of relatively fine spatial resolution; and 2) developing numerical procedures for estimating the total area of these cover types with low-resolution satellite imagery that incorporate models of size distribution and effects of pixelation.

Progress and results
At the outset of this project, previous research results had indicated that the distribution of sizes of small burn scars in tropical savannas and ponds in Arctic tundra could be modeled with power or exponential curves, and a comparison between fire scars observed with fine-scale imagery [Landsat multispectral scanner (MSS)] and low-resolution imagery [advanced very-high-resolution radiometer (AVHRIR)] had indicated effects of pixelation. Two additional Landsat data sets have been processed into maps of burn scars, and analysis of a map of surface water developed from 100 m Earth Resources Satellite (ERS-1) imagery has begun. Analysis of these additional maps of burn scars and ponds in tundra will support assessment of the variation of size distribution characteristics in space. A software module to simulate effects of pixelation was written as an initial step in developing procedures for improved areal estimates.

Significance of the results
The distributions of sizes of burn scars in tropical savannas and ponds in Arctic tundra indicate the important contribution of small patches, with sizes similar to or smaller than the pixels sizes of satellite imagery used for regional and global monitoring, to total area. The ability to model the distributions and simulate effects of pixelation is expected to lead improved areal estimates, which in turn will lead to better estimates of greenhouse gas production and effects on the energy balance between the Earth's surface and the atmosphere that are associated with biomass burning and high latitude wetlands.

Publications resulting from the study

Hlavka, C. A.; and Livingston, G. P.: Statistical Models of Fragmented Land Cover and the Effect of Coarse Spatial Resolution on the Estimation of Area with Satellite Sensor Imagery. International J. Remote Sensing, vol. 18, no. 10, 1997, pp. 2253–2259.

Hlavka, C. A.: Statistical Models of Landscape Pattern and the Effects of Coarse Spatial Resolution on Estimation of Area with Satellite Imagery. To be published in a book on spatial accuracy, co-edited by H. T. Mowrer and R. G. Congalton, by the Ann Arbor Press. In review.

Keywords
Satellite imagery, Spatial accuracy, Spatial resolution

Laminar Flow Fairings for Acoustic Sensors and Arrays

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Other personnel involved
Chris Allen, Ames Research Center

Objectives of the study
Recent wind tunnel aeroacoustic test programs have demonstrated the success of using multiple-sensor microphone arrays to measure the locations of noise sources due to high-lift systems and propulsion systems for both subsonic and supersonic transport aircraft configurations. Accurate measurement of clean and quiet configurations is presently a difficult challenge because of high background noise associated with turbulent flow over the sensor fairing. The present study investigates the feasibility and effectiveness of using natural laminar flow (NLF) and suction hybrid laminar flow (HLF) fairings to reduce the background noise and to control lift. The goal of this research is to generate design guidelines for fabrication of fairings for both small and large arrays for future aeroacoustic research.

Progress and results
The 14-inch subsonic wind tunnel in the Fluid Mechanics Laboratory has been adapted for development of quiet acoustic sensors, and common instrumentation and data-acquisition equipment will be used in the two studies. Two test models and a test section adapter have been designed, and fabrication is about 80 percent complete. The first test model is a NLF fairing with 8-inch chord and 5 microphones. The second model is a HLF model with 6-inch chord, 3 microphones, and 5 porous screen suction ports. The airfoil sections were adapted from the results of previous research studies and experiments of laminar flow and minimum turbulent separation configurations. Predictions of pressure distribution, transition, and separation locations have been computed for comparison with test results. Research testing should begin in late 1997 and be completed in early 1998.

Significance of the results
The development of microphone and acoustic array fairings with reduced background noise will enhance the value of aeroacoustic testing at Ames and at other research centers by allowing measurements at further distances, and will permit accurate measurements of clean (baseline) or advanced quiet transport configurations that use noise reduction technology. There are also commercial/military applications for low-background-noise acoustic sensors. These studies will also provide new insight into the role of acoustic receptivity and surface irregularities in boundary layer transition.

Keywords
Aeroacoustic testing, Acoustic arrays, Laminar flow

Calculation of the Free Energy, Thermal Energy, and Entropy of Self-Assembling Nanostructures in Solutions

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Timur Halicioglu, Eloret Institute, Ames Research Center

Objectives of the study

The configurational stability of nanoscale particles is greatly influenced by the surrounding medium. In general, the effect exerted by the medium on a transformation (or combination) reaction is a very important one, and can influence reaction equilibria and rates considerably. The objective of this study is to investigate the effect exerted by the solvent on a chemical system in equilibrium or undergoing reaction. The study is expected to provide an atomic level understanding of the contributions (coming from the enthalpy as well as the entropy) to various solvation processes and reaction equilibria and kinetics.

Progress and results

As a prototype system, the effect of aqueous solutions on the cis-trans isomerization reaction of azobenzene were considered. Investigations were conducted using a molecular dynamics procedure for T = 298 K and P = 1 atm. Simulation calculations were carried out employing the Dreiding force field method, and the Ewald sum technique was used to include long-range interactions. The enthalpy change, ΔH, for this isomerization reaction in the gas phase was well predicted. For the same reaction taking place in water, three main contributions (in order of importance) to ΔH coming from (1) changes in interaction energy among water molecules in the vicinity of azobenzene, (2) interactions between the azobenzene molecule and water, and (3) the strain energy of the azobenzene molecule due to different configurations were calculated.

Significance of the results

Results indicate that the contribution coming from water/water interactions, in the vicinity of the solute, plays the most important role in this isomerization reaction.

Keywords

Solvent effect, Azobenzene, Isomerization

Study and Design of Carbon Nanotube Electronic Devices

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Other personnel involved
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Objectives of the study

A carbon nanotube (CNT), a hollow cylinder formed by rolling over a graphene sheet, can be metallic or semiconducting, depending on the tube helicity and diameter. Because of its small feature size, ~1-nm diameter, CNTs can be used as quantum wires for single electron transistors or heterojunctions for diodes and transistors. The objective of this work is to explore, using quantum mechanics calculations and molecular simulations, the possibilities for making CNT nanoelectronic devices.

Progress and results

Three types of CNT devices have been designed and studied:

1. *CNT single electron transistor*
   Metallic 1.4-nm-diameter CNTs can be easily prepared. This CNT is recommended as a single electron transistor. On the scale of ~1-nm significant quantum jump effects due to transitions of a single electron are expected. The perfect tube, made of a hexagonal array of carbon atoms, is conducting because of the delocalized nature of the valence electrons. Topological defects can be created by converting four hexagons to a pentagon-heptagon-pentagon-heptagon configuration by rotating two adjacent carbon atoms in the surface of the cylinder. This scenario creates a barrier for electron transfer and can be considered to be a gate in the transistor. The chemical pathway for this transition and the chemical/mechanical stability of the defect site have been found by using quantum mechanics calculations and molecular simulations. Local density of states and conductance calculations suggest that this device could serve as a single electron transistor.
2. *Two-terminal CNT junction diodes*
   Scientists at the University of California, Berkeley, have proposed this type of device. The purpose of this research is to design synthetically accessible CNT junctions. Extensive ab initio calculations were performed to identify attractive candidates. These calculations were used to observe and collect samples of the simulated CNT structures. For these observed structures, electrical property calculations were performed to support further experimental studies. The collaborative work on measurement and modeling of the observed junctions is in progress.
3. *Three-terminal CNT junction transistors*
   Three-terminal Y and T CNT junctions based on analogs to conventional p-n-p or n-p-n junctions are proposed. The topological and chemical rules have been derived to construct these junctions. Some of the proposed structures have been observed experimentally, including T and Y junction and torus.

Significance of the results

On scientific issues, for the first time, the structural, chemical, mechanical, and electrical properties of CNTs have been correlated. Present research has shown that a small change in one property can result in a detectable change in other properties, suggesting that CNTs are ideal for nanoscale-mechanical-electrical systems (NEMS).

Technically, the designed CNT devices, if successful, can take us through the 0.1-micron barrier for feature size in conventional semiconductor materials. They could be used as computer components, including transistors, and also NEMS for sensors and interconnects.

Publications resulting from the study

Anantram, M. P.; and Han, J.: Transport through Uniform Carbon Nanotubes and Junctions. International Conference on Molecular Electronics: Science and Technology, Humacao, Puerto Rico, Dec. 14–18, 1997. http://science.nas.nasa.gov/~han/abstract/icmest97.html.

Han, Jie: Energetics and Structures of Carbon Nanoconic Tips and Nanotube Junctions. American Chemical Society National Meeting, Las Vegas, Nev., Sept. 7–11, 1997. http://science.nas.nasa.gov/~han/abstract/acs97.html.

Han, Jie: Energetics and Structures of Fullerene Crop Circles. Chem. Phys. Lett., Dec. 1997. http://science.nas.nasa.gov/~han/cone/cone.html.

Han, Jie: Modeling of Branched (L, Y and T) Carbon Nanotube Junctions. To be submitted to Phys. Rev. B. http://science.nas.nasa.gov/~han/LYTjunction/LYTjunction.html.

Han, Jie; Anantram, P. M.; Jaffe, R.; and Dai, H.: Observation and Modeling of Single Wall Carbon Nanotube Bend Junctions. Submitted to Phys. Rev. B, 1997. http://science.nas.nasa.gov/~han/bendjunction/bendjunction.html.

Han, J.; Anantram, M. P.; and Jaffe, R.: Design and Study of Carbon Nanotube Electronic Devices. Fifth Foresight Conference on Molecular Nanotechnology, Palo Alto, Calif., Nov. 1997. http://science.nas.nasa.gov/~han/abstract/fcmn1.html.

Han, Jie; and Jaffe, R.: Chemical and Mechanical Stability of Carbon Nanotube Electronic Devices. 1997 American Vacuum Society (AVS) Conference at San Jose, Calif., Sept. 28–31, 1997. http://science.nas.nasa.gov/~han/abstract/avs97b.html.

Han, Jie; and Jaffe, Richard: Energetics and Geometries of Carbon Nanoconic Tips. To appear in J. Chem. Phys., Feb. 1998. http://science.nas.nasa.gov/Pubs/TechReports/NASreports/NAS-97-015.

Han, Jie; and Jaffe, Richard: Roles of Pentagons and Heptagons in Carbon Nanotube Junctions. Submitted to Chem. Phys. Lett. http://science.nas.nasa.gov/~han/defect/defect.html.

Keywords

Carbon nanotube, Nanoelectronics, Junctions

Application of Unsteady CFD and Sensorless Adaptive Control for the Development of a Long-Term Left Ventricular Assist Device (LVAD)

Investigator(s)
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Cetin Kiris, MCAT Institute, Ames Research Center

Objectives of the study

To develop a procedure for designing a long-term or permanent ventricular assist device (VAD) by implementing adaptive control in conjunction with numerical simulations of time-varying pulsatile flow.

Progress and results

Mechanical blood pumping devices are in demand as a life support system to assist ailing hearts. Currently, the commercially available circulatory support involves large, complex, and expensive pulsatile devices. These diaphragm-type or cable-driven devices require large, external support equipment, resulting in little or no patient mobility.

In 1989, NASA/Johnson Space Center (JSC) began a joint project with the DeBakey Heart Center of the Baylor College of Medicine in Houston, Texas, to develop a new, implantable, total VAD (NASA/DeBakey VAD) complete with a control electronics package. This VAD is based on a fast-rotating axial pump that uses magnetic propulsion, requiring a minimum number of moving parts. To make it implantable, the device is to be made as small as possible, a stipulation that requires a very high rotational speed.

Depending on the usage, the requirements for VAD vary; they can be classified by the following three levels of operations:

Level 1: Two-Day Pump

This pump is used mainly after cardiovascular pulmonary bypass surgery. For this application, the hemolysis must be kept at a low level. Approximately 350,000 surgical procedures are performed each year.

Level 2: Two-Week Pump

This pump is used mainly for postsurgical heart failure and emergency cases. In addition to the low hemolysis, low blood clotting is required for this application. Approximately 25,000 patients need this treatment each year.

Level 3: Long-Term Pump

The long-term device is needed as a bridge to transplant or as a permanent assist device. For this purpose, sustained operation of five years or longer is desired. Each year approximately 60,000 patients need long-term support, while only 2000 to 2500 donor hearts are available.

In developing a short-term pump, two major problems associated with the original design are related to fluid dynamics: the excessive blood damage due to high shear stress and the low pumping efficiency, and blood clotting in the bearing region, which stops the pump after a short period of operation. To make this design usable, it was essential to lower the blood damage to an acceptable level and to increase pumping efficiency so that the power requirement can be minimized. In addition, stagnant regions need to be eliminated in the flow field, especially in the bearing region where blood clotting prevents the impeller from rotating. To complete the design effort, it was essential to quantify the flow characteristics under various combinations of geometry and operating conditions. The JSC/DeBakey design team requested that Ames Research Center (ARC) implement computational fluid dynamics (CFD) technology to analyze the flow in the device. NASA/ARC has been leading the development of CFD tools for incompressible flows for rocket propulsion and low-speed aerodynamic flow analysis. This technology is most suitable for analyzing the flow in VAD.

An extensive computational analysis resulted in numerous design modifications. A new idea of including an inducer between the flow straightener and the impeller was introduced, an idea that came directly from the work performed in conjunction with the next-generation liquid rocket propulsion system development with NASA's Marshal Space Flight Center. Although the inducer concept is being used in rocket engines, this is the first time an inducer was introduced in VAD.

Numerous design improvements were made through the use of CFD results on components such as blade shape, inducer gap, blade lean, and tapered hub step. An 11-day test was completed using the newest geometry. This test showed that no clotting occurred in the bearing region between the impeller and the diffuser. The final design has passed the two-week requirements.

During FY97, a representative unsteady flow profile from heart exit was given as an inflow to the inlet cannula to the VAD. The results have been analyzed to determine benefits of developing an adaptive control mechanism.

Significance of the results

The current design is compact and provides patient mobility. The major bottleneck has been the excessive thrombus and blood damage. The current effort resulted in the present design, which eliminates those problems and enables the device to be practically usable. An additional unsteady control mechanism will enhance patient mobility.

Publications resulting from the study

Kiris, C.; Kwak, D.; and Benkowski, R.: Incompressible Navier–Stokes Calculations for the Development of a Left Ventricular Assist Device. Accepted for publication in Computers and Fluids, 1997.

Kiris, C.; Kwak, D.; and Benkowski, R.: Computational Flow Analysis of a Left Ventricular Assist Device. Submitted to J. Artificial Organs.

Keywords

Biofluid computation, Ventricular assist device

Demonstration of a 7 Kelvin Pulse Tube Cooler Using Rare Earth Regenerators

Investigator(s)
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Other personnel involved
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Objectives of the study
To investigate and demonstrate a 7 K pulse tube cooler using rare earths as the regenerator material. Two coolers will be examined. The first will be tested using erbium-3-nickel (Er_3Ni) in the form of small-sized spheres (250-μm diameter) and the second will use neodymium (Nd)-stacked plates that are 150-μm thick and spaced 25 μm apart. These materials possess relatively high heat capacity at these low temperatures over existing lead regenerators. The increased heat capacity will lead to better-performing pulse tube coolers.

Progress and results
Preparation work for the demonstration is complete. The optimum sphere size, plate size, and plate spacing were calculated using a linearized, two-dimensional pulse tube model developed at Ames. The Er_3Ni spheres have been ordered. The Naval Surface Warfare Center, which is involved in fabricating Nd regenerators for low temperature coolers, has encouraged the present design and has recommended a source for fabricating the plates. The required instrumentation and data acquisition systems have been ordered. Last, a computational fluid dynamics (CFD) study has begun to further examine whether laminar or turbulent flow is better for these regenerators.

Significance of the results
This technology demonstration of the 7 K pulse tube will be important for future missions, such as to Mars, where the liquefaction of hydrogen will be required for fuel for returning to Earth.

Keywords
Pulse tube, Cryocooler, Regenerator

Wireless Video Measurements of Rotor Blade Displacement and Deformation

Investigator(s)
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Alan J. Wadcock, Sterling Software Systems, Ames Research Center

Objectives of the study
To demonstrate a portable system for the measurement of rotor blade displacement and deformation. Portability describes the self-contained nature of the proposed system, which requires ZERO slip ring channels for either signal transmission or power supply.

Progress and results
The following equipment has been procured:

- 200-MHz dual Pentium processor
- wireless video system for telemetry of the video signal from the hub-mounted video camera
- National Instruments frame grabber board and image acquisition software.

Operation of the image acquisition board has been verified at the required frame rates. In addition, researchers attended training classes on the NASA/High Technology Corporation second-generation Video Model Deformation System. This model deformation system developed at NASA Langley Research Center will be the backbone of the image-processing system.

Keywords
Rotor, Displacement, Video

Validation of a Nose-Channel Concept for Supersonic Drag Reduction

Investigator(s)

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Objectives of the study

To conduct an experimental proof-of-concept study to validate the computationally predicted drag reduction at supersonic speeds for a body with a hollow channel extending from the nose to the trailing edge. This objective is being accomplished by measuring the lift and drag performance (from time of arrival and shadowgraph image trajectory analysis) of conventional and channeled axisymmetric sphere/cone models flying in the Ames Ballistic Range.

Progress and results

Significant progress has been made in establishing the viability of the nose-channel concept as an effective drag reduction technique. Navier–Stokes simulations of airfoils and axisymmetric bodies with and without channels indicate that the nose-channel concept significantly reduces total drag and increases the lift/drag. A reduction in sonic boom signature was also predicted. Experimental channeled and conventional models have been designed and fabricated, and will be tested in the Ames Ballistic Range at Mach 2.5. As shown in figure 1, pretest computational comparisons predict an 11-percent drag reduction, and a 60-percent increase in lift/drag from the nose-channel concept model.

The nose-channel concept has potential for high payoff. For planetary-entry, hypersonic, and supersonic-cruise vehicles, drag reduction and increased lift/drag can lead to greater range capability, increased payload mass fraction, improved fuel efficiency, and enhanced maneuverability. The channel concept is potentially useful in drag and sonic boom signature reduction applications.

The next phase of the investigation will focus on making high-fidelity measurements of lift and drag versus angle of attack from trajectory analysis of Ballistic Range sphere/cone nose-channel concept models. Concurrently, sonic boom pressure signature measurements will also be made to validate predicted reductions for nose-channel configurations. Computational and experimental investigations of more complicated three-dimensional (3-D) bodies will also be explored.

Publications resulting from the study

Ruffin, S. M.; and Gupta, A.: Supersonic Channel-Airfoils for Reduced Drag. AIAA Paper 97-0517, Jan. 1997.

Keywords

Drag, Lift/drag ratio, Channel

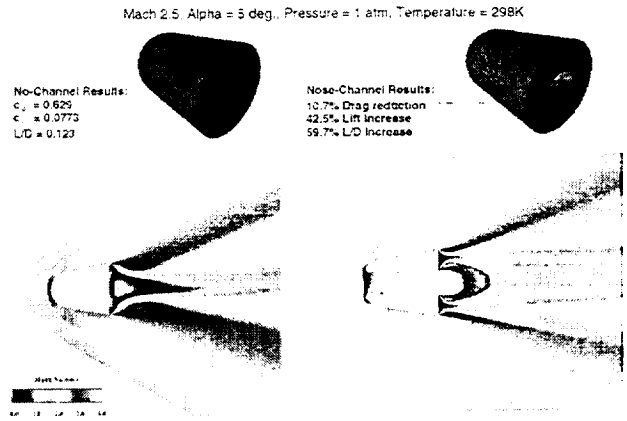

Figure 1. Computational fluid dynamics (CFD) simulations—experimental models.

Simulation Modeling Investigations of the Terrestrial Carbon Cycle

Investigator(s)
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Other personnel involved
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Vanessa Brooks, Johnson Controls World Services, Ames Research Center

Objectives of the study
To overcome most of the significant technical obstacles to development of a computing and visualization framework that will help in coupling and testing model algorithms of physical and biogeochemical controllers on carbon trace gas emissions from a dynamic global land surface simulation.

Progress and results
A prototype model design that uses data collected at various validation sites located throughout the terrestrial biosphere is now in test phase. This dynamic global vegetation model (DGVM) is being closely coupled to the NASA–Carnegie-Ames-Stanford Approach (CASA) trace gas model of Potter and Klooster (ref. 1), which includes calibration of seasonal phenology algorithms using global satellite data. The coupled DGVM design is based conceptually on two main elements of Tilman's (1985) resource-ratio hypothesis of vegetation change: (1) plant competition for resources (water and light) over relatively short time periods of months and seasons; and (2) the long-term pattern in the supply of growth-limiting resources such as water and nutrients; i.e., the resource-supply trajectory.

Significance of the results
When completed, this dynamic ecosystem model, which will run on a regional or global grid structure, will help enable scientific investigations of transient biosphere interactions with atmospheric chemistry and climate on a planetary scale. It will be among the first ecosystem models to include process-oriented controls over global hydrologic, energy, and ecosystem trace gas exchange with a changing land surface. This general outcome is a crucial element of the Strategic Plan for NASA's Mission to Planet Earth (MTPE).

Publications resulting from the study
An article has been submitted to the Ecological Soc. of Am. Bull. (Number 78).

Reference

Potter, C. S.; and Klooster, S. A.: Global Model Estimates of Carbon and Nitrogen Storage in Litter and Soil Pools: Response to Changes in Vegetation Quality and Biomass Allocation. Tellus Series B—Chemical and Physical Meteorology, vol. 49, no. 1, Feb. 1997, pp. 1–17.

Keywords
Carbon cycle, Ecosystem modeling, Climate change

Adaptation of Bone to Mechanical Stimulation: Development and Characterization of a Unique Osteoblast Loading System

Investigator(s)

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Other personnel involved

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Objectives of the study

1) To develop a cell loading system for investigation of the biochemical and structural response of cells to cyclic mechanical loading. The cell loading system will (a) load each cell uniformly and physiologically; (b) dynamically load cells with cyclic tensile and compressive mechanical deformation; (c) apply shear stress to cells via fluid flow; and (d) permit real-time microscopic observations of the cells at a single set-point in each loading cycle.

2) To perform scientific characterization tests demonstrating that the loading system will support the intended science. Engineering tests will confirm load uniformity and reproducibility. Biological tests using rat osteoblasts, or bone forming cells, will include measurements of cell shape, orientation, differentiation, and maturation. Immunofluorescence localization of cytoskeletal and extracellular matrix components will demonstrate that the required features of cellular and extracellular structure can be imaged in cells grown in the loading system.

3) To develop a model based on structural analyses to predict changes in the cell shape, orientation, and structure, depending on the applied load. Three-dimensional cell shapes will be measured using nonpenetrating fluorescent dyes, and combined with data from Objective 2 to support model development.

Progress and results

The loading system has been designed that will load the cells uniformly and physiologically with cyclic tensile and compressive mechanical deformation, and will permit real-time microscopic observations of the cells at a single set-point in each loading cycle. A prototype apparatus has been constructed, and biocompatibility of cell chamber materials has been demonstrated. Compatibility of cell chamber materials with both real-time phase contrast microscopy and fixed cell immunocytochemistry has been tested. The cell chamber design has evolved, chamber prototypes have been built and tested, and a final design for mechanical deformation studies has been selected. Biocompatibility tests in the cell chambers showed that osteoblasts differentiated normally and produced bone nodules. The loading frame and drive system have been designed and integrated with the cell chambers and a computer control system. Initial engineering load uniformity tests have been completed. Tests of cells in the integrated loading system are in progress. Cytoskeletal and extracellular matrix proteins in osteoblasts have been localized in control, stationary cultures using immunocytochemistry techniques, and cell orientation has been determined using phase microscopy.

Significance of the results

A unique system has been developed that will permit the investigation of the effects of physiological levels of mechanical loads on the morphology and function of osteoblasts. Completion of the science investigations will determine the role of the osteoblast's cytoskeleton and attachments to the extracellular matrix in responding to mechanical loads. Determination of the mechanisms that osteoblasts use to respond to mechanical loading will lead to a better understanding of the role osteoblasts play in situ in bone as they adapt bone structure in response to daily mechanical loads generated by physical activities, such as walking, or reduced activity, as seen in spaceflight. In addition, the loading system has broader applications, including determining the response to mechanical

stimulation of other cell types, such as osteoclasts, osteocytes, endothelial, and muscle cells.

Keywords
Mechanical loading, Osteoblast, Mechanical strain

Dexterous Walking for Mobility in Unstructured Terrain

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John Bares and Dimitrious Apostolopolous, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA 15213

Objectives of the study

To develop gait planning and control for high-degree-of-freedom, walking robots with application to locomotion in unstructured, rough terrain. This effort will develop new control techniques for dexterous walking and mobility, with an emphasis on behavior- and neural-based methods. In addition, these control techniques will allow the integration with reactive and deliberative control methodologies. To support development of these new algorithms, both a virtual environment simulator and a walking mechanism hardware testbed will be developed to demonstrate rough-terrain locomotion.

Progress and results

The hardware, software, and programmatic infrastructure has been built. The basic electrical and mechanical design for the walking robot testbed has been developed, and detailed mechanical design for the legs has begun. The virtual environment simulator is being developed.

The basic walking chassis under development is a radially symmetric hexapod with orthogonal legs (fig. 1). This leg/body configuration allows the unconstrained body translation regardless of yaw. Each leg comprises three degrees of freedom: a rotary hip, a prismatic knee, and a prismatic foot. The hip and knee joints operate in the horizontal plane, while the foot operates in the vertical plane. This leg configuration decouples horizontal and vertical body motion, minimizing the overall energy consumed by locomotion, since support can be achieved via mechanical braking of the vertical actuator. The necessary motors and control amplifiers for all six legs have been purchased.

The control system of the walking robot testbed allows for hybrid torque-position control over all 18 degrees of freedom in the walking robot. Joint feedback is generated by joint position sensors (potentiometers), semiconductor strain gauges, and contact switches in the foot. In addition, attitude feedback is generated by a compass-inclinometer. The control system consists of a 68060 processor with 20 12-bit analog output channels, 56 12-bit analog input channels, and 40 digital channels. Analog inputs are used to measure strain gauge and potentiometer signals, and analog output is used to drive pulse-width modulated (PWM) amplifiers, which in turn drive the motors.

The control system of the walker has been integrated with a graphical, virtual environment simulator, which simulates the inputs from feedback sensors and the joint responses and allows high-level planning algorithms to be tested. The simulator is implemented on an SGI workstation using the VEVI software package.

Significance of the results

The ability to locomote efficiently and autonomously on harsh planetary surfaces is a key requirement for the exploration of the solar system. The results to date will allow development and evaluation of advanced gait control algorithms, making walking a viable locomotion technique for NASA missions. In addition, the mechanical configuration being developed is optimized around power consumption and maneuverability, key factors in the design of surface exploration systems.

Keywords

Legged locomotion, Walking, Planning, Robot navigation, Planetary rovers

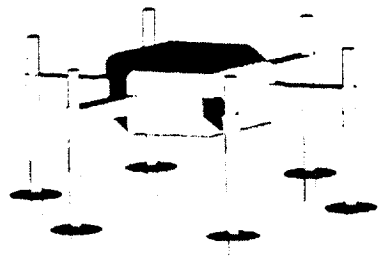

Figure 1 . Omnidirectional hexapod.

The Origin and Control of 3-D Phenomena in Nominally 2-D Flows

Investigator(s)
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Jonathan H. Watmuff, MCAT Institute, Ames Research Center

Objectives of the study

Observation of nominally two-dimensional (2-D) (including axisymmetric) flows reveals an almost universal tendency to develop localized three-dimensional (3-D) phenomena that can dominate the behavior of the flow. Laminar flows are specially susceptible to this tendency. Accurate, experimentally verified computation of this type of behavior has not been demonstrated, for even the simplest of flows; e.g., prediction of transition to turbulent flow is notoriously inaccurate.

The prevailing view is that the final stage of transition involves the onset of 3-D characteristics in 2-D Tollmien–Schlichting (TS) waves that originate upstream. Considerable effort has been devoted to studying the nonlinear development of TS waves in an effort to identify the origin of the 3-D developments. However, there is evidence to suggest that other phenomena, which are unrelated to TS waves, may play a potentially more significant role in promoting 3-D effects. These phenomena have been largely overlooked.

The most clearly evident phenomena are weak streamwise vortices (also known as Klebanoff modes) that introduce spanwise variations of the boundary layer thickness.

The objectives of this study are:

1. To gain a fundamental understanding of the underlying physical processes leading to the formation of streamwise vortices in nominally 2-D stagnation flows.
2. To explore the role of local pressure gradient as a parameter for controlling the subsequent development of streamwise vortices as the leading edge flow is blended into a 2-D flat-plate zero pressure gradient (ZPG) Blasius boundary layer.
3. To explore the stability characteristics (e.g., growth rate) of streamwise vortices in a Blasius boundary layer.
4. To explore conditions under which interactions between the vortices and other disturbances (e.g., TS waves) are favorable (e.g., suppression of TS wave growth) or detrimental (e.g., secondary instabilities associated with the vortices).
5. To develop more sophisticated methods for quantifying wind tunnel flow quality.

Progress and results

The experiments are performed in a dedicated, small-scale, standalone wind tunnel with a highly uniform free stream ($\Delta U/U_1 < 0.05$ percent) and an extremely low background disturbance level ($u/U_1 < 0.05$ percent). (U is the streamwise component of the temporal mean velocity, u is the root mean square of the streamwise velocity of fluctuations, and the subscript 1 refers to free stream.) Detailed measurements are made in a Blasius boundary layer with an exceptionally low background disturbance level ($u/U_1 < 0.08$ percent for $Re = 0.7 \times 10^6$) and with a high degree of spanwise uniformity.

The wake behind a fine wire has been explored as a means of deliberately introducing a small nonuniformity into the mean flow for the purpose of stimulating the formation of streamwise vortices in the boundary layer. The technique consists of stretching a fine wire normal to the flow and normal to the leading edge some distance upstream. Two wire diameters are used; i.e., $d = 25$ μm (0.001 inch), corresponding to Reynolds numbers based on the wire diameters of $R_d = 16.7$ and $R_d = 33.4$, respectively. The strength of the wake behind the wires ranges from 1 to 3 percent of the free-stream velocity.

Interaction of wake behind the wire with the leading edge leads to the formation of a pair of weak streamwise vortices in the boundary layer. The vortices are associated with local regions of elevated unsteadiness that occur at frequencies very much lower than the instabilities predicted from linear stability theory. The vortices are also associated with a local increase in the thickness of the boundary layer.

The most recent results are remarkable since they demonstrate the formation of vortices in the layer, even when the $d = 50$ μm wire is located

diameters upstream of the leading edge (i.e., upstream of the contraction) and the strength of the wake is less than 0.02 percent of the free-stream velocity.

Significance of the results

The association of premature transition to turbulence with free-stream nonuniformity has important implications for wind tunnel model tests and the issue of flow quality.

The detrimental effect of the vortices is demonstrated by showing that the growth of TS waves is more rapid in the local region of increased boundary layer thickness between the vortices. The increased growth rate ultimately leads to premature transition to turbulence farther downstream.

Publications resulting from the study

Watmuff, Jonathan H.: Advanced Flow Diagnostics for Laminar Flow Control and Low Disturbance Facilities. MCAT Inst. Progress Report for Performance Period 11/1/95 to 10/31/96. Contract NAS2-14109, Task Number 5, October 1996.

Watmuff, Jonathan H.: Interactions between Klebanoff Modes and TS Waves in a Blasius Boundary Layer. AIAA Paper 97-0558, presented at the 35th AIAA Aerospace Sciences Meeting and Exhibit, Reno, Nev., Jan. 6–10, 1997.

Tobak, M.: Topologically Derived Separation Onset Conditions for Two- and Three-Dimensional Laminar Flows. AIAA Paper 97-0866, presented at the 35th AIAA Aerospace Sciences Meeting and Exhibit, Reno, Nev., Jan. 6–10, 1997.

Watmuff, Jonathan H.: Detrimental Effects of Almost Immeasurably Small Free-Stream Nonuniformities Generated by Wind Tunnel Screens. AIAA Paper 97-0228, presented at the 35th AIAA Aerospace Sciences Meeting and Exhibit, Reno, Nev., Jan. 6–10, 1997.

Watmuff, Jonathan H.; and Tobak, M.: Flow Quality and Boundary Layer Transition. Bull. Am. Phys. Soc., 1997 (to appear).

Keywords

Streamwise vortices, Tollmien–Schlichting waves, Flow quality

Super Low Thermal Conductivity and Low-Density Ablative Composites

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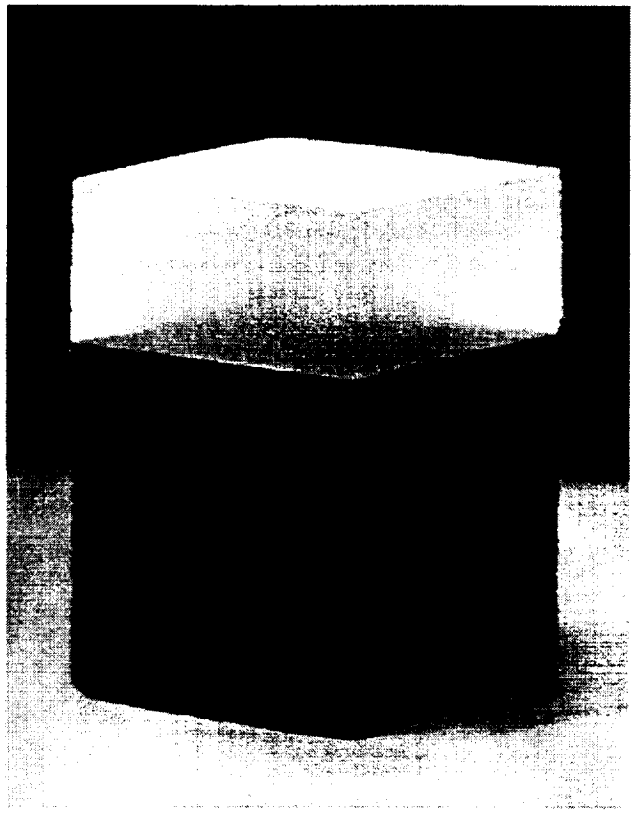


Objectives of the study
To demonstrate the feasibility of chemically combining aerogel technology with the latest light-weight ceramic ablator material to produce an ultralow thermal conductive in-depth material with high ablative performance at the outer surface. This objective is being accomplished by integrating the aerogel material for its super insulative properties and different light ceramic ablators material for their ablative characteristics.

Progress and results
Samples of aerogel material obtained from the Lawrence-Livermore National Laboratory (LLNL) were successfully bonded on the phenolic impregnated carbon ablator (PICA) without difficulty. Thermal conductivity of the system is being measured as a function of temperatures and pressures.

Keywords
Aerogel, Ablative materials, Planetary entry, Heat shield, Thermal protection system (TPS)

A Deployable Vortex Diffuser for Reducing Blade-Vortex Interaction Noise

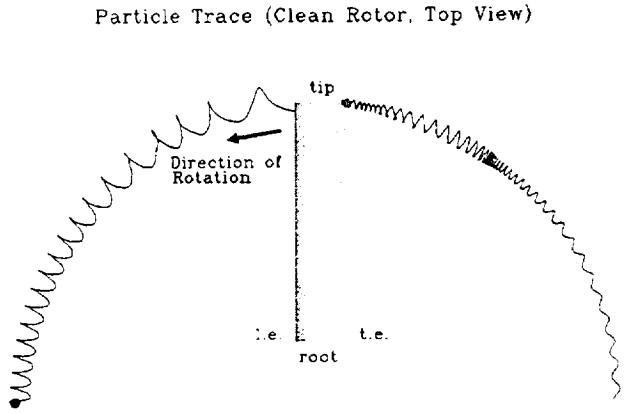
Investigator(s)
Chee Tung and Ken McAlister, Ames Research Center, Moffett Field, CA 94035-1000

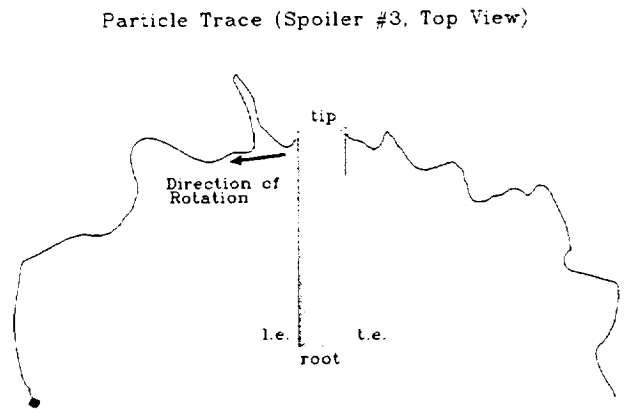
Objectives of the study
To change the structure of the trailing vortex of helicopter rotor blades by reducing the magnitude of its peak velocity. The civilian helicopter fleet cannot reach full potential because of the noise level during descent into heliports near communities. Much of the noise comes from rotor blades cutting through their own wake—a phenomenon referred to as blade-vortex interaction (BVI) noise.

Progress and results
The computational fluid dynamics (CFD) solutions of a candidate trailing-edge spoiler have been completed.

Significance of the results
The peak velocity of the trailing vortex has been reduced by 30 percent. The particle traces in the figures show that the vortex structure has been altered by the trailing-edge spoiler.

Keywords
Rotor wake, Blade/vortex interaction, Deployable spoiler





Adaptation to Virtual Gravitational Environments

Investigator(s)
Robert B. Welch, Ames Research Center, Moffett Field, CA 94035-1000

Michael Aratow, Ames Research Center Associate

Robert Whalen, Ames Research Center

Wanda L. Boda, Sonoma State University, Sonoma, CA 95476

Alan Hargens, University of California, San Diego, Ames Research Center

Objectives of the study
To (1) simulate many of the bodily and visual effects of ambulating on Mars by means of a combination of lower body positive pressure and a computer-generated virtual environment with which the subject interacts by means of a motor-driven treadmill on which he/she walks; and (2) demonstrate that human beings are able to adapt their walking behavior to this simulation while simultaneously maintaining their ability to walk in the normal (1-g) environment.

Keywords
Preflight adaptation training, Mars, Reduced gravity

Fastenerless Structural Connections for Tiltrotor Aircraft

Investigator(s)
John Zuk, Ames Research Center,
Moffett Field, CA 94035-1000

Clem Hiel, W. B. Goldsworthy & Assoc., Inc.,
23930-40 Madison St., Torrance, CA 90505

Objectives of the study
To conduct innovative research leading to the development of a new class of fastenerless connections, called "snap joints," for assembly of composite structures, with special emphasis on tiltrotor aircraft.

Progress and results
Ideas for snap joints have been formulated. Conceptual designs utilizing computer-aided design (CAD) have been developed, and candidate test specimens have been fabricated and developed. A full-scale generic snap joint illustrating ease of assembly and positive interlocking features has been fabricated.

A new snap joint filter architecture has been fabricated and tested; results were compared with a current state-of-the-art laminated fiber architecture.

Significance of the results
The new snap joint architecture increased the interlaminar shear strength by at least a factor of five. Plans include a patent application and an industrial partnership.

Keywords
Composites, Snap joints

Appendix A-1
Final Reports

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Software Interface Analysis Tool (SIAT)

Investigator(s) (show affiliation)

John C. Hinkle, NASA Software IV&V Facility; Steven Easterbrook, West Virginia Univ.; Randy Hefner, Intermetrics

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house 0

Contracts (identify) $40,000 (Intermetrics, Inc.)

Grants (identify) 0

Expected completion date 9/30/97

Authorized in FY 97 $40,000

Requested for FY ___ (If any)

Status of Study

☒ Completed in FY ___ ☐ Continued in FY ___

If continued in FY ___ ☐ With funds remaining? ☐ With FY ___ funds?

If transitioned to other funding, to RTOP (number?) ARC05N UPN 323-08

to Program (name?)

to Other (identify)

Purpose of investigation

To improve effectiveness, productivity, and quality of external interface source code analysis for large, complex, distributed systems being developed in the Ada programming language.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The SIAT phase 1 prototype has been demonstrated and is planned for utilization on the International Space Station (ISS) Independent Verification and Validation (IV&V) contract. It has already been deployed at the NASA Software IV&V Facility in Fairmont, West Virginia, and is soon to be deployed at the IV&V site in Houston, Texas.

Planned future work

SIAT phase 2 development has been awarded under Center Initiative number ARC05N.

Prepared by	Org. Code	M/S	Phone
John C. Hinkle	IT		(304) 367-8205

ARC 735 (Sep 97)E Previous editions are obsolete

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

The Development of a Micromachined Gas Chromatography System for Future Planetary Missions

Investigator(s) (show affiliation)

Daniel R. Kojiro, ARC; Thomas C. Shen, SETI Institute, ARC; James T. Suminto, MicroTech Scientific, Inc.

Funding

Year Initiated FY95

Total prior to FY 97 $40,000

Total expended in FY 97 (Estimated)

In-house $21,000

Contracts (identify) $19,000 (MicroTech Scientific, Inc.)

Grants (identify)

Expected completion date 9/30/97

Authorized in FY 97 $40,000

Requested for FY 98 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☒ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?) 344-36-20-24

to Program (name?) Planetary Instrument Definition and Development Program

to Other (identify)

Purpose of investigation

To develop lightweight, low-power, micromachined, gas chromatographic equipment for future planetary atmospheric probes and soil gas or pyrolytic analysis. A gas chromatography (GC) instrument was used for the Pioneer Venus mission. However, future missions, such as the Mars Exploration Missions, discover missions, and missions to probe outer planet atmospheres or outer planet moons, will require further reduction in weight, volume, and power requirements.

FY 96 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Received 1996 Planetary Instrument Definition and Development Program (PIDDP) award for continued R&D support.

Planned future work

Future work plan has been developed and described in the PIDDP proposal.

Prepared by	Org. Code	M/S	Phone
Thomas C. Shen	SSX	239-12	(650) 604-5769

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Planetary Wind Sensor

Investigator(s) (show affiliation)

Paul Kolodziej and Louis J. Salerno, ARC; David W. Bogdanoff, Thermosciences Institute; Gregory Wilson, Arizona State Univ.

Funding

Year Initiated FY 96

Total prior to FY 97 $40,000

Total expended in FY 96 (Estimated)

In-house $25,000

Contracts (identify) $15,000 (Thermosciences Institute)

Grants (identify)

Expected completion date 9/30/97

Authorized in FY 97 $40,000

Requested for FY ___ (If any)

Status of Study

☒ Completed in FY 97 ☐ Continued in FY ___

If continued in FY ___ ☐ With funds remaining? ☐ With FY ___ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To accurately measure wind velocities in a low-density environment such as the Martian atmosphere (approximately 6 mbar). The objective is to develop a low-power, lightweight, reliable, and cost-effective means of sensing wind speeds and direction for current and future planetary exploration programs. This objective is being accomplished by modification of an existing, commercially available wind speed and direction sensor that employs ultrasonic transducers as sensing elements.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Measurements were made in the Ames Aeolian Research Facility at reduced pressures. A commercially available sensor employing ultrasonic transducers successfully operated down to 110 mbar.

Planned future work

To improve the sensitivity of the sensor further, a novel concept employing a spark generator in conjunction with ultrasonic piezoelectric transducers is expected to extend the usable range of the sensor to measurement of wind velocities at pressures down to 6 mbar or less, while maintaining low cost, simplicity, and reliability.

Prepared by	Org. Code	M/S	Phone
Louis J. Salerno	STM	234-1	(650) 604-3189

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Quantitative Characterization of Porous TPS Microstructures Using Laser Scanning Confocal Microscopy

Investigator(s) (show affiliation)

Frank Milos, ARC; Jochen Marschall, Eloret Institute; Joanne Frerich, Sandia National Laboratories

Funding

Year Initiated FY96

Total prior to FY 97 $40,000

Total expended in FY 97 (Estimated)

In-house $20,000

Contracts (identify) $20,000 (Sandia National Labs*)

Grants (identify)

Expected completion date 9/30/97

Authorized in FY 97 $40,000

Requested for FY 98 0 (If any)

Status of Study

☒ Completed in FY 97 ☐ Continued in FY ___

If continued in FY 98 ☐ With funds remaining? ☐ With FY ___ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To explore the capability of laser scanning confocal microscopy (LSCM) to provide quantitative information about the porous microstructure of various thermal protection system (TPS) materials. The idea is to use LSCM to obtain digitally stored representations of the pore structure and to devise computational algorithms to extract numerical values for such quantities as porosity, surface area per volume, pore size and orientation distributions, etc. This information will then be incorporated into various modeling efforts, such as, e.g., internal radiation transport and gas flow in fibrous insulations.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Preliminary results from this work were presented at the Workshop on Thermalphysical Phenomena in Microscale Sensors, Devices, and Structures, Baltimore, Maryland, Aug. 1997. Further publication and presentation of the results are anticipated.

Planned future work

A manuscript that details the application of LSCM to obtain quantitative microstructural information on highly porous fibrous materials is being prepared.

A study to compare experimental permeability measurements with LSCM-based model computations of permeability will be concluded. It is anticipated that the results of this study will be presented or published.

*Purchase Order No. A49107D (SLS)

Prepared by	Org. Code	M/S	Phone
Jochen Marschall	STM	234-1	(650) 604-0829

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation
NASA Ames Astrobiology Academy

Investigator(s) (show affiliation)
Douglas A. O'Handley, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house

Contracts (identify) $66,000 (Lockheed Martin Missiles & Space)

Grants (identify)

Expected completion date 9/30/97

Authorized in FY 97 $66,000

Requested for FY (If any)

Status of Study

☒ Completed in FY 97 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?) Astrobiology

to Other (identify)

Purpose of investigation

To help guide future leaders of the U.S. Space Program by giving them a glimpse of how NASA operates. Applicants are chosen for this summer institute for their scientific accomplishments, scholarly achievement, and individuality. Another goal is to provide insight into all the elements that make the NASA missions possible, while at the same time assigning the student to one of NASA's best researchers to contribute toward one of its missions.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The efforts of one student are expected to lead to a publication in the scientific literature: Ross, Muriel; and Hand, Kevin: Biocomputation: 3-D Visualization of Adaptive Changes in Gravity Sensors in the Space Environment.

Planned future work

As a result of the success of the first Ames Astrobiology Academy, we are planning to host another Academy in 1998. The Academy will be expanded to accommodate 15 students, and will thus allow greater participation with Ames principal investigators. This program will evolve continually. It is expected that Kennedy Space Center will be the fifth NASA Center to host students in this manner.

Prepared by	Org. Code	M/S	Phone
Douglas A. O'Handley	SS	245-1	(650) 604-3525

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Does Ultraviolet Radiation Affect Carbon Isotope Fractionation?

Investigator(s) (show affiliation)

Lynn Rothschild, David Des Marais, ARC; Aruna Balakrishnan, student programs; Anne Tharpe, ManTech Systems Engrg. Corp.

Funding

Year Initiated FY96

Total prior to FY 97 $40,000

Total expended in FY 97 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/97

Authorized in FY 97 $40,000

Requested for FY 98 0 (If any)

Status of Study

☒ Completed in FY 97 ☐ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☐ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To determine if ultraviolet (UV) radiation affects stable carbon isotope ratios. If so, is there an ecologic (e.g., microbial mat vs. phytoplankton) or taxonomic (e.g., prokaryote vs. eukaryote, alga vs. plant) correlation with the effect? These data will provide the basis to present the phenomenon to the scientific community, to estimate how widespread the phenomenon is, and to suggest ways to begin to elucidate the mechanisms underlying the effect. Ultimately this work could lead to a re-interpretation of isotopic ratio studies, including a re-interpretation of the fossil record.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Data on the isotopic effect of UV radiation were presented at the IAI Workshop on UV in the Marine Environment in Baja, Mexico.

Planned future work

Prepared by	Org. Code	M/S	Phone
Lynn Rothschild	SGE	239-12	(650) 604-6525

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Use of Evolving Microbial Systems as a Domain for Development of Autonomous Artificial Intelligence Software

Investigator(s) (show affiliation)

David Thompson, ARC; P. Robinson, Caelum-Recom Tech., ARC; R. Mancinelli, D. Smernoff, M. White, SETI Inst., ARC

Funding

Year Initiated FY95

Total prior to FY 97 $40,000

Total expended in FY 97 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/97

Authorized in FY 98

Requested for FY 98 (If any)

Status of Study

☒ Completed in FY 97 ☐ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☐ With FY 97 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To achieve advances in artificial intelligence (AI)-based software technology for control, diagnosis, and repair of complex microbial experimental systems, and to gain a better understanding of the role that nitrogen-fixing and denitrifying microbial systems play in nutrient cycling, atmospheric evolution, and biogeochemical (BGC) cycles on Earth.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Smernoff, D. T.; and Mancinelli, R. M.: Co-organizers of a Half-Day Symposium on the Bioreactor System, in the 1998 International Society for Ecological Modeling Program "Issues in Trophic Systems Synthesis," Ecol. monographs, 1998 (in preparation).

Robinson, Peter: Autonomous Design and Execution of Process Controllers for Untended Scientific Instruments, Proceedings of the 1997 1st International Conference on Autonomous Agents, Marina del Rey, Calif., Feb. 5–8, 1997, ACM SIGART, New York, N.Y., pp. 546–547.

Planned future work

An integrated hardware and software system will be used for ongoing studies of nutrient cycling mediated by microbes and control of denitrification by microbes in closed systems. Autonomy features will be developed further, and new subsystem controllers based on quantitative and qualitative system models will be added. Export technologies (denitrification control and autonomy features) will be applied to advanced life support systems.

Prepared by	Org. Code	M/S	Phone
David Smernoff/Rocco Mancinelli	SSX	239-12	(650) 604-1230

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Modeling High-Energy Aerocapture Trajectories for Outer Planet Orbiter Missions

Investigator(s) (show affiliation)

Paul Wercinski, ARC; Periklis Papadopolous, Ethiraj Venkatapathy, Thermosci. Inst.; Y-K. Chen, ARC; Lily Yang, Sterling, ARC

Funding

Year Initiated FY96

Total prior to FY 97 $40,000

Total expended in FY 97 (Estimated)

In-house

Contracts (identify) $40,000 (Thermosci. Inst., Sterling)

Grants (identify)

Expected completion date 9/30/97

Authorized in FY 97 $40,000

Requested for FY ___ (If any)

Status of Study

☒ Completed in FY 97 ☐ Continued in FY ___

If continued in FY ___ ☐ With funds remaining? ☐ With FY ___ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

The objectives of the proposed research are threefold. The first objective is to characterize the static aerodynamic coefficients of the axisymmetric biconic shape in realistic flow conditions representative of actual flight trajectory. This would include the lift and drag coefficients of the entry vehicle at various angles of attack. The second objective is to calculate the heating distribution over the surface of the entry vehicle at various trajectory points. The last objective is to determine TPS requirements from the coupled heating distributions at several trajectory points. With this analysis, an attempt to incorporate approximate methods of estimating the heating distribution (and subsequent thermal protection material requirements) with an actual trajectory simulation will be assessed and performed if appropriate.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

DDF study results will be presented to Outer Planet mission planners at the Jet Propulsion Laboratory in 1998.

Prepared by	Org. Code	M/S	Phone
Paul Wercinski	STA	230-2	(650) 604-3157

Appendix A-2
Ongoing Reports

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Gas-Phase Spectroscopy of Interstellar PAH Analogs

Investigator(s) (show affiliation)

Lou Allamandola, ARC; Farid Salama, SETI Institute, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $50,000

Contracts (identify)

Grants (identify)

Expected completion date 1/1/99

Authorized in FY 97 $50,000

Requested for FY 98 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To investigate the potential interrelationship between interstellar polycyclic aromatic hydrocarbons (PAHs) and the carriers of the diffuse interstellar bands (DIBs). The goal is to measure, for the first time, the gas-phase spectra of selected neutral and ionized interstellar PAH analogs to allow a decisive test for these species as potential DIB carriers. These goals can be achieved by using the combined techniques of supersonic free-jet expansion spectroscopy (JES) and laser absorption spectroscopy (LAS).

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

A feasibility study of the project has been performed and a new experimental setup for a jet supersonic expansion has been designed. The optimal characteristics (diameter of the nozzle, size and structure of the expansion chamber, pressure range) have been calculated for the generation of a supersonic jet with the appropriate temperature for a correct simulation of the diffuse interstellar medium. The vacuum hardware (expansion chamber and precision manipulators), the pulsed nozzle, and the pumping stations have been either built and/or ordered.

Planned future work

The supersonic jet expansion chamber will be mounted and the first ultraviolet, visible, and near-infrared spectra of a few selected, free, molecular PAHs in their neutral and ionized forms will be measured.

Prepared by	Org. Code	M/S	Phone
Farid Salama	SSA	245-6	(650) 604-3384

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Development of a Tethered-Glider Probe-Positioning System for Use in Wind Tunnel Testing

Investigator(s) (show affiliation)

Dale L. Ashby, ARC; Hiroyuki Kumagai, AerospaceComputing, Inc.

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $7500

Contracts (identify) $27,500 (ACI); $5000 (Calspan)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 97 $40,000

Requested for FY 98 $40,000
(If any)

Status of Study

☐ Completed in FY ___ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To demonstrate the feasibility of using a tethered glider as a minimally intrusive, probe-positioning system in a wind tunnel environment. The new probe-positioning system, if successful, would provide a cheaper, more flexible means of conducting flow surveys with probes such as hot wires or seven-hole probes in a large wind tunnel such as the National Full-Scale Aerodynamics Complex (NFAC). The capabilities of an onboard, miniature data acquisition system and a flight-control system will also be demonstrated. If the tethered glider concept proves feasible, future enhancements to the system will include incorporating a propulsion system for increased positioning flexibility.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The design and analysis of the glider airframe is currently under way. Aerodynamic analysis to design and establish stability derivatives is being done using PMARC, a potential flow code. The flight-control computer hardware and control servos have been procured, and flight-control software is being written. The inertial navigation system for determining attitude and position has been defined and is currently being procured. A secondary position and attitude sensing system is being evaluated. The integration of the miniature data-acquisition system has been completed.

Planned future work

Planned work for FY98 includes construction of the glider and installation of the servos for moving control surfaces. The miniature data-acquisition system and flight-control system will then be installed in the glider. A flight test will be conducted to verify flight controls and glider performance. The tether system required for wind tunnel operation will be designed and assembled. The probe position and attitude determination system will also be completed. The complete probe-positioning system will then be tested in the NFAC in late FY98 or early FY99.

Prepared by	Org. Code	M/S	Phone
Dale Ashby	AAL	247-2	(650) 604-5047

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Visual Servo-Control Applied to Mobile Robot Navigation

Investigator(s) (show affiliation)

Maria Bualat, Hans Thomas, David Wettergreen, Gary Haith, ARC; Matt Deans, Carnegie Mellon Univ.

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 5/31/99

Authorized in FY 97 $40,000

Requested for FY 98 $40,000
(If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop a visual approach to short-range and terminal mobile robot navigation. Visual servo-control techniques for mobile robots will be developed; these techniques will be implemented on board under realistic computing and telemetry constraints; analogous obstacle-avoidance techniques will be developed; performance will be quantified and compared to traditional methods; and this approach will be demonstrated in realistic field experiments.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

None.

Planned future work

Methods for improving performance will be applied; and the visual servoing technique will be tested using low-mounted, fixed cameras to simulate conditions for near-term rover missions to Mars.

Prepared by	Org. Code	M/S	Phone
Maria Bualat/Hans Thomas	IC	269-3	(650) 604-4250

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Active Control of Instability Waves in a Laminar Boundary Layer

Investigator(s) (show affiliation)

Sanford Davis, ARC; Anthony Dietz, MCAT Institute, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $24,000

Contracts (identify) $16,000 (MCAT Institute, ARC)

Grants (identify)

Expected completion date 10/31/98

Authorized in FY 97 $40,000

Requested for FY 98 $40,000
(If any)

Status of Study

☐ Completed in FY ___ ☒ Continued in FY 98

If continued in FY ___ ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop and test an active wave cancellation scheme for boundary layer transition control. The control unit consists of an array of microphones and speakers mounted in a cavity beneath the surface of a flat plate. Initial development and testing is carried out with the plate boundary layer excited by artificially generated two- and three-dimensional free-stream disturbances in a low-speed wind tunnel. These repeatable disturbances provide a known input to the control system, allowing detailed studies of the cancellation process and optimization of the control algorithms. When a satisfactory control scheme has been developed, it will be evaluated against random three-dimensional instability wave packets excited by free-stream turbulence.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

None.

Planned future work

Testing and optimization of the control algorithms will continue in the next fiscal year.

Prepared by	Org. Code	M/S	Phone
Sanford Davis / Anthony Dietz	ADF	260-1	(650) 604-4137

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

The Early History of the Biogeochemical Carbon Cycle Can Be Illuminated by Isotopic Microanalyses of Rocks Using a UV Laser

Investigator(s) (show affiliation)

David J. Des Marais, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 10/31/98

Authorized in FY 97 $40,000

Requested for FY 98 $40,000
(If any)

Status of Study

☐ Completed in FY 97 ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To demonstrate the suitability of an ultraviolet laser to extract carbon from geological samples and fresh organic matter for stable isotopic analysis. To combine a laser, microscope, sample positioning stage, and sample chamber swept by a gas stream to gather sample gas. To demonstrate that analyses can be obtained at levels of accuracy and precision required for geochemical interpretation of the origin of the phases under study. Commercially available components must be integrated with a new sample chamber, and an isotope mass spectrometer system most suitable for the isotopic analysis must be selected.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

The components will be integrated into a complete laser ablation system. The system will be calibrated using standard carbonates and graphitic carbon. First, measurements of geologic materials will be performed and compared with previous measurements obtained by whole rock analysis and microdrilling. First attempts will be made to perform microcombustion of organic matter in an oxygen atmosphere, followed by sweeping the combustion products into the GC-IRMS using a helium stream. The system will be calibrated for research use.

Prepared by	Org. Code	M/S	Phone
David Des Marais	SSX	239-4	(650) 604-3220

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Remembering To Do Things in Dynamic Environments

Investigator(s) (show affiliation)

Key Dismukes, Roger Remington, and Maria Stone, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 97 $40,000

Requested for FY 98 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

Prospective memory demands arise when one forms an intention to perform an action that must be deferred until later. That intention must be held in memory. Thus a memory load is created that is subject to forgetting. In fact, numerous instances of prospective memory errors have been reported in daily life and in safety-critical operations. This investigation examines the nature of prospective memory in tasks such as those performed by air traffic controllers. It will help elucidate the factors that influence success or failure in controllers' memory tasks. Knowledge gleaned in this study should enable improvements in controller training and in task design to reduce errors in prospective memory performance.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

With the experimental paradigm that has been developed, data will be collected on the effect on prospective memory of factors such as the duration an intention must be retained in memory, the availability and character of cues to remind the subject of the intention, the workload on the ongoing task, and the relation of the prospective task to the ongoing task.

Prepared by	Org. Code	M/S	Phone
Key Dismukes	AF	262-4	(650) 604-0150

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Martian Fossils in the ALH84001 Meteorite: An Independent Assessment of the Evidence

Investigator(s) (show affiliation)

Jack D. Farmer and David Blake, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $21,000

Contracts (identify) $19,000 (SETI)

Grants (identify)

Expected completion date 10/31/98

Authorized in FY 97 $40,000

Requested for FY 98 $40,000
(If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To re-evaluate the biogenicity of microfossil-like features found in the Martian meteorite, ALH84001, based on detailed comparisons to terrestrial analogs of known origin. To achieve this goal we seek to: 1) use nutrient limitation methods to derive an empirically based estimate for the lower size limit achieved by four species of small heterotrophic microbes from hydrothermal environments considered good analogs for ALH84001; 2) re-evaluate the biogenicity of features commonly found in terrestrial rocks that have been broadly referred to as "nanobacteria"; 3) document the effects of contemporaneous mineralization on the fossilization potential of small bacteria, particularly those found in hydrothermal environments; and 4) make direct mineralogical and microstructural comparisons of terrestrial analogs of known origin and the putative nanometer-scale microfossils of the ALH84001 meteorite.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

1) Complete detailed morphometric comparison of experimental cultures; 2) continue nutrient limitation experiments at levels of 1 and 0.1 percent to evaluate the effects of prolonged starvation; 3) undertake a transmission electron microscope study of experimental cultures to observe changes in internal cell structure under starvation and to compare spore morphologies for each species; 4) induce carbonate precipitation within live cultures to observe the mechanisms of fossilization at the nanometer scale; 5) make quantitative morphometric comparisons of terrestrial analog materials and putative microfossils in ALH84001, and develop an archive of results that identifies reliable criteria for assessing biogenicity of microfossil-like structures in ancient rock materials; and 6) present results at ALH84001 Meteorite session at Lunar Planetary Science Conference, and prepare a manuscript for publication.

Prepared by	Org. Code	M/S	Phone
Jack D. Farmer	SSX	239-4	(650) 604-5748

ARC 735 (Sep 97)E Previous editions are obsolete

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Remote Sensing of Aircraft Contrails Using a Field Portable Imaging Interferometer

Investigator(s) (show affiliation)

Philip D. Hammer, ARC; William H. Smith, Washington University, St. Louis; Stephen Dunagan and Anthony Strawa, ARC

Funding

Year Initiated FY95

Total prior to FY 97 $40,000

Total expended in FY 97 (Estimated)

In-house $35,000

Contracts (identify)

Grants (identify) $5000 (Washington U. Consortium)

Expected completion date 10/31/98

Authorized in FY 97 $40,000

Requested for FY 98 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☒ With funds remaining? ☐ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To measure visible and infrared radiative effects of aircraft contrails to provide information about their spatial distributions, their microphysical properties (especially ice crystals), their time evolution, and their surroundings. This objective is being accomplished by applying a novel remote sensing technique, imaging interferometry, which provides two-dimensional spectral images of contrails and other atmospheric features of interest.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

An improved digital array scanned interferometry (DASI) sensor is being developed for the near infrared.

Planned future work

To make additional ground-based measurements of aircraft contrails after acquiring a new lens system for the infrared DASI sensor. The improved infrared instrument will permit obtaining images with good spatial resolution over the entire spectral range of 4000 to 11,000 cm–1 (0.91 to 2.0 microns). The anticipated high-quality measurements will enable completion of the study.

Prepared by	Org. Code	M/S	Phone
Philip Hammer	SGE	242-4	(650) 604-3383

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

A Modeling Approach to Global Land Surface Monitoring with Low-Resolution Satellite Imagery

Investigator(s) (show affiliation)

Christine A. Hlavka, ARC; Jennifer Dungan, JCWS; Gerry P. Livingston, U. of Vermont

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $30,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 97 $30,000

Requested for FY 98 $30,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop a new approach to computing accurate estimates of global extents of land use/land cover types with maps derived from satellite imagery. This objective is being accomplished by: 1) testing models of the size distribution of patches of specific cover types, as mapped with imagery of relatively fine spatial resolution; and 2) developing numerical procedures for estimating the total area of these cover types with low resolution satellite imagery that incorporate models of size distribution and effects of pixelation.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Hlavka, C. A.; and Livingston, G. P.: Statistical Models of Fragmented Land Cover and the Effect of Coarse Spatial Resolution on the Estimation of Area with Satellite Sensor Imagery. International J. Remote Sensing, vol. 18, no. 10, 1997, pp. 2253–2259.

Hlavka, C. A.: Statistical Models of Landscape Pattern and the Effects of Coarse Spatial Resolution on Estimation of Area with Satellite Imagery. To be published in a book on spatial accuracy, co-edited by H. T. Mowrer and R. G. Congalton, by the Ann Arbor Press. In review.

Planned future work

Current data analyses will be completed and additional data sets will be analyzed to characterize the distribution of area as a function of patch size, including maps developed from Radarsat imagery. Simulations of size distributions will be developed and compared to those measured on digital maps. Procedures for correcting for pixelation effects and estimating parameters of the underlying size distribution will be developed and tested.

Prepared by	Org. Code	M/S	Phone
Christine A. Hlavka	SGE	242-4	(650) 604-3328

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation
Laminar Flow Fairings for Acoustic Sensors and Arrays

Investigator(s) (show affiliation)
Clifton Horne, Kevin James, and Chris Allen, ARC

Funding

Year Initiated FY97

Total prior to FY ____

Total expended in FY 97 (Estimated)

In-house $8000

Contracts (identify) $22,000 (Calspan Corp.; design, fabrication)

Grants (identify) ____

Expected completion date 1/1/99

Authorized in FY 97 $30,000

Requested for FY 98 $50,000
(If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) ____

to Other (identify) ____

Purpose of investigation

To determine the feasibility and effectiveness of using natural laminar flow (NLF) and hybrid laminar flow (HLF) fairings to reduce the background noise of inflow sensors and multiple sensor arrays required for wind tunnel aeroacoustic test programs; to investigate flow-acoustic interactions associated with boundary layer transition processes on sensor fairings in envirnoments typical of wind tunnels used for aeroacoustic research; and to compare background noise levels of new concepts to isolated microphones with quiet forebodies (baseline).

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

The experimental investigation, analysis, and reporting of data will continue. A preliminary design of a demonstration experiment in the 40- by 80-Foot Subsonic Wind Tunnel will be initiated, as well as a preliminary design of a large array fairing for wind tunnel research.

Prepared by	Org. Code	M/S	Phone
Clifton Horne	AAL	247-2	(650) 604-4571

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Calculation of the Free Energy, Thermal Energy, and Entropy of Self-Assembling Nanostructures in Solutions

Investigator(s) (show affiliation)

Richard L. Jaffe, ARC; Timur Halicioglu, Eloret Institute, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house

Contracts (identify) $40,000 (Eloret Institute)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 97 $40,000

Requested for FY 98 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

Self-assembling systems are of importance in molecular biology and nanotechnology. In trying to determine whether a solute will spontaneously self-assemble, one must understand the role of the solvent. The purpose of this investigation is to study the effect exerted by the solvent on a chemical system in equilibrium or undergoing reaction. We want to provide an atomic level understanding of the contributions from enthalpy and entropy to various solvation processes and reaction equilibria and kinetics.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Study solvation effects on the stability of weakly bonded molecular complexes involving both hydrophobic and hydrophilic interactions.

Prepared by	Org. Code	M/S	Phone
Timur Halicioglu	STC	230-3	(650) 604-1388

ARC 735 (Sep 97)E Previous editions are obsolete

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Study and Design of Carbon Nanotube Electronic Devices

Investigator(s) (show affiliation)

Richard L. Jaffe, ARC; Jie Han, MRJ, Inc., ARC; P. M. Anantram, ARC; H. Dai, Stanford U.

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $12,000

Contracts (identify) $8000 (Eloret Inst.)

Grants (identify)

Expected completion date 10/31/99

Authorized in FY 97 $20,000

Requested for FY 98 $60,000 (If any)

Status of Study

☐ Completed in FY ___ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

A carbon nanotube (CNT), a hollow cylinder formed by rolling over a graphene sheet, can be metallic or semiconducting, depending on the tube helicity and diameter. Because of its small feature size, ~1-nm diameter, CNTs can be used as quantum wires for single electron transistors or heterojunctions for diodes and transistors. The objective of this work is to explore, using quantum mechanics calculations and molecular simulations, the possibilities for making CNT nanoelectronic devices.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Anantram, P. M.; and Han, J.: Transport through Uniform Carbon Nanotubes and Junctions. International Conference on Molecular Electronics: Science and Technology, Humacao, Puerto Rico, Dec. 14–18, 1997. http://science.nas.nasa.gov/~han/abstract/icmest97html.

Han, Jie: Energetics and Structures of Fullerene Crop Circles. Chem. Phys. Lett., Dec. 1997. http://science.nas.nasa.gov/~han/cone/cone.html.

For a more comprehensive list of publications, see report in this document.

Planned future work

Study will continue on different designs for quantum wires, single-electron transistors, heterojunction diodes and transistors, and mechanical/electric devices, with increased emphasis on calculating electric properties for realistic conditions. Collaboration with experimental work to build and test prototype devices will continue.

Prepared by	Org. Code	M/S	Phone
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Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Application of Unsteady CFD and Sensorless Adaptive Control for the Development of a Long-Term LVAD

Investigator(s) (show affiliation)

Dochan Kwak, ARC; Cetin Kiris, MCAT Institute, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $18,000

Contracts (identify)

Grants (identify) $22,000 (MCAT Institute, ARC)

Expected completion date 10/31/98

Authorized in FY 97 $40,000

Requested for FY 98 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 87

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To apply computational methods for developing a long-term or a permanent ventricular assist device (VAD) by implementing adaptive control in conjunction with numerical simulations of time-varying pulsatile flow.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Various inflow cannula designs have been analyzed using a representative pulsatile flow condition from the heart. The VAD itself has been developed and tested based on constant average blood flow rate. The current pulsatile flow analysis will help define the overall performance and will be a guide for an optimum implantation configuration. The computed results have been postprocessed in movie format. The combined experimental and computational results will be used in an application to the Food and Drug Administration for human implantation.

A U.S. patent application was filed on Dec. 13, 1996, entitled "Rotary Blood Pump" (Serial # 08/766,886).

Kiris, C.; Kwak, D.; and Benkowski, R.: Incompressible Navier–Stokes Calculations for the Development of a Left Ventricular Assist Device. Accepted for publication in Computers and Fluids, 1997.

Kiris, C.; Kwak, D.; and Benkowski, R.: Computational Flow Analysis of a Left Ventricular Assist Device. Submitted to J. Artificial Organs.

Planned future work

The next challenge is to integrate the sensorless adaptive control and the flow simulation procedure for the development of a long-term VAD. Through a full, unsteady simulation from inlet cannula to the exit of the VAD, requirements for an adaptive control can be defined. In FY98, a fully unsteady solution procedure for the entire VAD installation geometry will be developed and implemented.

Prepared by	Org. Code	M/S	Phone
Dochan Kwak	ADC	T27B-1	(650) 604-6743

ARC 735 (Sep 97)E Previous editions are obsolete

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Demonstration of a 7 Kelvin Pulse Tube Cooler Using Rare Earth Regenerators

Investigator(s) (show affiliation)

Jeffrey M. Lee and Peter Kittel, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $20,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 97 $40,000

Requested for FY 98 $40,000
(If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To investigate and demonstrate a 7 K pulse tube cooler using rare earths as the regenerator material. Two coolers will be examined. The first will be tested using erbium-3-nickel (Er_3Ni) in the form of small-sized spheres (250-μm diameter) and the second will use neodymium (Nd)-stacked plates that are 150-μm thick and spaced 25 μm apart. These materials possess relatively high heat capacity at these low temperatures over existing lead regenerators. The increased heat capacity will lead to better-performing pulse tube coolers.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

None at this time.

Planned future work

Construction of the 7 K pulse tube will be completed, and tests to measure performance will be conducted. Heat lifted, cold temperature, pressure oscillations, work input, and efficiency will be measured; the data will be compared to present models and to previous cooler systems; and the results will be published in an appropriate peer-reviewed journal.

Prepared by	Org. Code	M/S	Phone
Jeffrey Lee	SFT	244-10	(650) 604-5693

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Wireless Video Measurements of Rotor Blade Displacement and Deformation

Investigator(s) (show affiliation)

Douglas L. Lillie, ARC; Alan J. Wadcock, Sterling Software, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $30,000

Contracts (identify)

Grants (identify)

Expected completion date 10/31/99

Authorized in FY 97 $30,000

Requested for FY 98 $50,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To demonstrate a portable system for the measurement of rotor blade displacement and deformation. Portability of the system is used to describe the self-contained nature of the proposed system, which requires ZERO slip ring channels for either signal transmission or power supply.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

None.

Planned future work

Plans are to:
(1) Identify suitable power packs for camera and strobe.
(2) Develop strobe control hardware and image acquisition software.
(3) Design and build hardware for camera calibration.
(4) Perform static checkout of the video telemetry system.
(5) Check out rotating system.

Prepared by	Org. Code	M/S	Phone
Alan Wadcock	ARA	T12-B	(650) 604-4573

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Validation of a Nose-Channel Concept for Supersonic Drag Reduction

Investigator(s) (show affiliation)

Mark E. Newfield, ARC; Stephen M. Ruffin, Georgia Institute of Technology

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 10/30/99

Authorized in FY 97 $40,000

Requested for FY 98 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To conduct an experimental proof-of-concept study to validate the computationally predicted drag reduction at supersonic speeds for a body with a hollow channel extending from the nose to the trailing edge. This objective is being accomplished by measuring the lift and drag performance (from time of arrival and shadowgraph image trajectory analysis) of conventional and channeled axisymmetric sphere/cone models flying in the Ames Ballistic Range.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Ruffin, S. M.; and Gupta, A.: Supersonic Channel-Airfoils for Reduced Drag. AIAA Paper 97-0517, Jan. 1997.

Planned future work

Research will focus on making high-fidelity measurements of lift and drag versus angle of attack from trajectory analysis of Ballistic Range sphere/cone nose-channel concept models. Concurrently, sonic boom pressure signature measurements will also be made to validate predicted reductions for nose-channel configurations. Computational and experimental investigations of more complicated three-dimensional (3-D) bodies will also be explored.

Prepared by	Org. Code	M/S	Phone
Mark E. Newfield	STA	230-2	(650) 604-4893

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Simulation Modeling Investigations of the Terrestrial Carbon Cycle

Investigator(s) (show affiliation)

Christopher Potter, ARC; Steven Klooster, California State University; Vanessa Brooks, JCWS, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $5000

Contracts (identify) $35,000 (JCWS Services, ARC)

Grants (identify)

Expected completion date 1/9/99

Authorized in FY 97 $40,000

Requested for FY 98 $40,000
(If any)

Status of Study

☐ Completed in FY ___ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To overcome most of the significant technical obstacles to development of a computing and visualization framework that will help in coupling and testing model algorithms of physical and biogeochemical controllers on carbon trace gas emissions from a dynamic global land surface simulation.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

A manuscript has been submitted to the Ecological Society of America Bulletin.

Planned future work

When completed, a developed dynamic ecosystem model, which will run on a regional or global grid structure, will help enable scientific investigations of transient biosphere interactions with atmospheric chemistry and climate on a planetary scale. It will be among the first ecosystem models to include process-oriented controls over global hydrologic, energy, and ecosystem trace gas exchange with a changing land surface. This general outcome is a crucial element of the Strategic Plan for NASA's Mission to Planet Earth (MTPE).

Prepared by	Org. Code	M/S	Phone
Christopher Potter	SGE	242-4	(650) 604-6164

ARC 735 (Sep 97)E Previous editions are obsolete

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Adaptation of Bone to Mechanical Stimulation: Development and Characterization of a Unique Osteoblast Loading System

Investigator(s) (show affiliation)

Nancy D. Searby, Emily Morey-Holton, and Ruth Globus, ARC; Ekhson Holmuhamedov, Mayo Clinic

Funding

Year Initiated FY96

Total prior to FY 96 $40,000

Total expended in FY 97 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 10/30/98

Authorized in FY 97 $40,000

Requested for FY 98 0 (If any)

Status of Study

☐ Completed in FY ___ ☒ Continued in FY 98

If continued in FY 98 ☒ With funds remaining? ☐ With FY ___ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To determine the role of the cytoskeleton and attachments to the extracellular matrix in the response of bone-forming cells, called osteoblasts, to mechanical loads. To accomplish this, an apparatus is under development that provides mechanical loads to osteoblasts in culture. Experiments using this apparatus will lead to a better understanding of the role that osteoblasts play in situ as they modify bone structure in response to altered mechanical loads, as generated by physical activities or exposure to spaceflight.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The prototype loading system has been developed, and is presently undergoing engineering performance, cell biocompatibility, and science characterization testing. Osteoblast cytoskeletal and extracellular matrix proteins were effectively localized. Use of the loading system was proposed in response to a NASA Research Announcement, and will be included in future proposals.

Planned future work

Engineering performance and cell biocompatibility testing will be completed, the computer control system will be enhanced, and additional loading systems will be constructed to generate a sufficient number of samples for statistical analysis of the results obtained from experiments. Science studies will be performed to investigate the effects of mechanical loading on cytoskeletal and extracellular matrix proteins of osteoblasts, and initial feasibility of constructing a model based on a structural analysis of the cell's response to loads will be assessed.

Prepared by	Org. Code	M/S	Phone
Nancy Searby	SLR	236-7	(650) 604-6794

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Dexterous Walking for Mobility in Unstructured Terrain

Investigator(s) (show affiliation)

Michael Sims, David Wettergreen, Hans Thomas, ARC; John Bares, Dimitrious Apostolopolous, Carnegie Mellon Univ.

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 97 $40,000

Requested for FY 98 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop gait planning and control for high-degree-of-freedom walking robots with application to locomotion in unstructured, rough terrain. This effort will develop new control techniques for dexterous walking and mobility, with an emphasis on behavior- and neural-based methods. In addition, these control techniques will allow the integration with reactive and deliberative control methodologies. To support development of these new algorithms, both a virtual simulator and a walking mechanism hardware testbed will be developed to demonstrate rough-terrain locomotion.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

None.

Planned future work

The hardware testbed will be completed and then application of new control techniques will be carried out.

Prepared by	Org. Code	M/S	Phone
Hans Thomas/Michael Sims	IC	269-3	(650) 604-5562

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

The Origin and Control of 3-D Phenomena in Nominally 2-D Flows

Investigator(s) (show affiliation)

Murray Tobak, ARC; Jonathan H. Watmuff, MCAT Institute, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 10/31/98

Authorized in FY 98 $40,000

Requested for FY 98 $40,000
(If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To investigate the phyical processes leading to the formation of weak streamwise vortices in nominally two-dimensional (2-D) boundary layer flows.
To explore the role of pressure gradient as a parameter for controlling the subsequent development of the vortices.
To explore the stability characteristics of the streamwise vortices.
To explore conditions under which interactions between the vortices and other disturbances [e.g., Tollmien–Schlichting (TS) waves] are favorable (e.g., suppression of TS wave growth) or adverse (e.g., increased TS growth leading to premature transition to turbulence).

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Watmuff, Jonathan H.; and Tobak, M.: Flow Quality and Boundary Layer Transition. Bull. Am Phys. Soc., 1997 (to appear).

Planned future work

Testing of the effect of the wire wake-induced vortices will continue. Multiple wires will be used to explore sensitivity to spanwise length scale. Motion of the wire will be used to explore the dynamic sensitivity.

Prepared by	Org. Code	M/S	Phone
M. Tobak / J. H. Watmuff	ADF	260-1	(650) 604-5855

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Super Low Thermal Conductivity and Low-Density Ablative Composites

Investigator(s) (show affiliation)

Huy Tran and Christine Johnson, ARC

Funding

Year Initiated FY96

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $20,000

Contracts (identify) $20,000 [LLNL (see IASA*)]

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 97 $40,000

Requested for FY 98 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 98

If continued in FY 98 ☐ With funds remaining? ☒ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To demonstrate the feasibility of chemically combining aerogel technology with the latest lightweight ceramic ablator material to produce an ultralow thermal conductive in-depth material with high ablative performance at the outer surface. This objective is being accomplished by integrating the aerogel material for its super insulative properties and different light ceramic ablators material for their ablative characteristics.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

After the purchase request is processed by our procurement office, LLNL will start making the aerogel in conjunction with lightweight ceramic ablators (LCAs). Also, arcjet testing is planned to evaluate the material ablation characteristic as well as the thermal response. Virgin LCA samples will be tested as a baseline for comparison. Crush properties of the system are also being investigated.

*Interagency Space Act

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Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

A Deployable Vortex Diffuser for Reducing Blade-Vortex Interaction Noise

Investigator(s) (show affiliation)

Chee Tung and Ken McAlister, ARC

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 5/1/99

Authorized in FY 97 $40,000

Requested for FY (If any)

Status of Study

☐ Completed in FY ___ ☒ Continued in FY 98

If continued in FY 98 ☒ With funds remaining? ☐ With FY ___ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To change the structure of the trailing vortex of helicopter rotor blades by reducing the magnitude of its peak velocity. The civilian helicopter fleet cannot reach full potential because of the noise level during descent into heliports near communities. Much of the noise comes from rotor blades cutting through their own wake—a phenomenon referred to as blade-vortex interaction (BVI) noise.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The computational fluid dynamics (CFD) solutions of a candidate trailing-edge spoiler have been completed. Use of the spoiler produced the peak velocity of the trailing vortex. Results from this study were presented at the Director's Discretionary Fund poster session on November 4, 1997.

Planned future work

A hover test will be performed to quantify the performance of a static vortex spoiler design. The results are expected to indicate the presence of strong turbulent mixing and a decrease in the strength of the vortex. A mechanism for deploying the spoiler on the blade will be designed.

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Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Adaptation to Virtual Gravitational Environments

Investigator(s) (show affiliation)

R. B. Welch, ARC; M. Aratow, ARC Assoc.; R. Whalen, ARC; W. L. Boda, Sonoma State U.; A. Hargens, UC, San Diego, ARC

Funding

Year Initiated FY96

Total prior to FY 97 0

Total expended in FY 97 (Estimated)

In-house $70,000

Contracts (identify)

Grants (identify)

Expected completion date 10/31/98

Authorized in FY 97 $70,000

Requested for FY 98 $30,000 (If any)

Status of Study

☐ Completed in FY ___ ☒ Continued in FY 98

If continued in FY 98 ☒ With funds remaining? ☐ With FY 98 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To (1) simulate many of the bodily and visual effects of ambulating on Mars by means of a combination of lower body positive pressure and a computer-generated virtual environment with which the subject interacts by means of a motor-driven treadmill on which he/she walks; and (2) demonstrate that human beings are able to adapt their walking behavior to this simulation while simultaneously maintaining their ability to walk in the normal (1-g) environment.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

To (1) determine the optimal training procedures for producing adaptation and dual adaptation to the Mars Gravity Simulator; and (2) examine various parameters of this adaptation, such as its longevity, the best discriminative cues for dual adaptation, and the generalizability of adaptation and dual adaptation to other environments.

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Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1997

Title of Investigation

Fastenerless Structural Connections for Tiltrotor Aircraft

Investigator(s) (show affiliation)

John Zuk, ARC; Clem Hiel, W. B. Goldsworthy & Assoc., Inc.

Funding

Year Initiated FY96

Expected completion date 10/31/98

Total prior to FY 97 $40,000

Authorized in FY 97 $40,000

Total expended in FY 97 (Estimated)

Requested for FY ___ (If any)

In-house

Contracts (identify) $40,000 (Sci. Appl. Int'l. Corp.)

Grants (identify)

Status of Study

☐ Completed in FY ___ ☒ Continued in FY 98

If continued in FY 98 ☒ With funds remaining? ☐ With FY ___ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To conduct innovative research leading to the development of a new class of fastenerless connections, called "snap joints," for assembly of composite structures, with special emphasis on tiltrotor aircraft.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Fabricated and tested a new snap joint fiber architecture and compared results with a current state-of-the-art laminated fiber architecture. The new snap joint architecture increased the interlaminor shear strength by at least a factor of five. Results were reported in an article in SAMPE J., vol. 35, no. 1, Jan./Feb. 1998.

Planned future work

(1) Redesign a generic composite component on a tiltrotor aircraft using snap joint fastening. Conduct design, development, and payoff studies.
(2) Seek funding for continuing activity from a new funding source.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 1998	Technical Memorandum

4. TITLE AND SUBTITLE
Director's Discretionary Fund Report for Fiscal Year 1997

5. FUNDING NUMBERS
274-53-71-39

6. AUTHOR(S)
Ames-Moffett Investigators

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Ames Research Center
Moffett Field, CA 94035-1000

8. PERFORMING ORGANIZATION REPORT NUMBER
A-98-08589

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA/TM—1998-112216

11. SUPPLEMENTARY NOTES
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12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified — Unlimited
Subject Category 99

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This technical memorandum contains brief technical papers describing research and technology development programs sponsored by the Ames Research Center Director's Discretionary Fund during fiscal year 1997 (October 1996 through September 1997). Appendices provide administrative information for each of the sponsored research programs.

14. SUBJECT TERMS
Director's Discretionary Fund, Space science, Life science, Aeronautics, Space and terrestrial applications

15. NUMBER OF PAGES
88

16. PRICE CODE
A05

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified		